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ABSTRACT

This publication, developed by the Oregon Department of Education, presents a framework for science programs designed to help teachers organize their science curriculum to be consistent with Oregon's goal-based planning for K-12 instruction. It consists of six major sections. Section one presents the framework for Oregon's goal-based science curriculum which considers state goals, district goals, program goals, and course goals. This section also discusses competencies and presents goals of individual students. Section two presents sample activities which may take place in science classrooms. The first 12 activities treat science instruction itself. They consist of four in earth science (one each for K-3, 4-6, 7-9, 10-12), four in life science, and four in physical science. The next 20 activities illustrate how other special interests (prekindergarten, reading, math, career education, handicapped) may interact with the science curriculum. Section three presents safety in science programs. Section four presents assessing science programs. Section five presents resources. Section six contains an appendix which includes sample course goals, self-assessment checklist for science teachers, and procedures for developing staff agreement. (HM)

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FRAMEWORK FOR SCIENCE PROGRAMS

Verne A. Duncan
State Superintendent of Public Instruction

Oregon Department of Education
Salem, Oregon 97310
1979

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FOREWORD

Framework for Science Programs suggests a way teachers may organize science curriculum consistent with Oregon's goal-based planning for K-12 instruction. Sample activities illustrate what may take place in science classrooms K-3, 4-6, 7-9, 10-12. Sample activities also illustrate how other special interests—prekindergarten, reading, math, career education, handicapped—may influence science curriculum . . . and vice versa.

And all these activities may be done safely. Teachers and students can create for themselves safe learning environments.

Verne A. Duncan
State Superintendent
of Public Instruction

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GOAL-BASED PLANNING FOR SCIENCE

Oregon manages K-12 instruction by means of **GOAL-BASED PLANNING** (*not* competency-based education).

Goals are guideposts. They serve to give purpose and direction to a planning activity. Goals provide a common language for discussing the merits of various activities as those activities are carried out.

In science, just as in any other instructional program offered by an educational system, a sense of purpose and direction is essential to good planning. But what are these purposes and directions? Where do they come from? Why should the science teacher be concerned? These are questions to be answered before effective planning of a science curriculum can proceed.

Each teacher must realize that planning a science curriculum cannot begin and end only in a given classroom. It needs to be done with a sense of similar planning in other classrooms and districts within the state.

The goals and goal-setting and competency-identification activities the Oregon Department of Education prescribes provide districts a common reference for the planning process. In goal-based planning, teachers must consider four goals: State Goals for Oregon Learners, district goals, program goals, course goals.

STATE GOALS answer the question: What does the Department of Education think a student should get out of public schooling anywhere in Oregon?

DISTRICT GOALS answer the question: What do the local community and its schools think a student ought to get out of local schooling and how is that to relate to State Goals?

PROGRAM GOALS answer the question: What do the local curriculum planners and science teachers think a student ought to get out of science and how is that to relate to District Goals?

COURSE GOALS answer the question: What do the science teachers think a student ought to get out of, say, Biology I and how is that to relate to Program Goals?

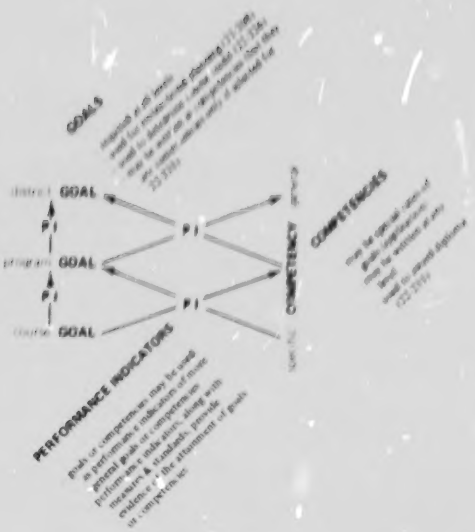
Where, then, does competency fit in goal-based planning?

It fits as a separate but related design. It is merely one of three graduation requirements. Districts plan and evaluate instruction by means of GOALS, *goals local districts themselves write*. Districts assess whether students get diplomas by means of COMPETENCY, CREDIT and ATTENDANCE, *requirements local districts themselves fix minimums for*.

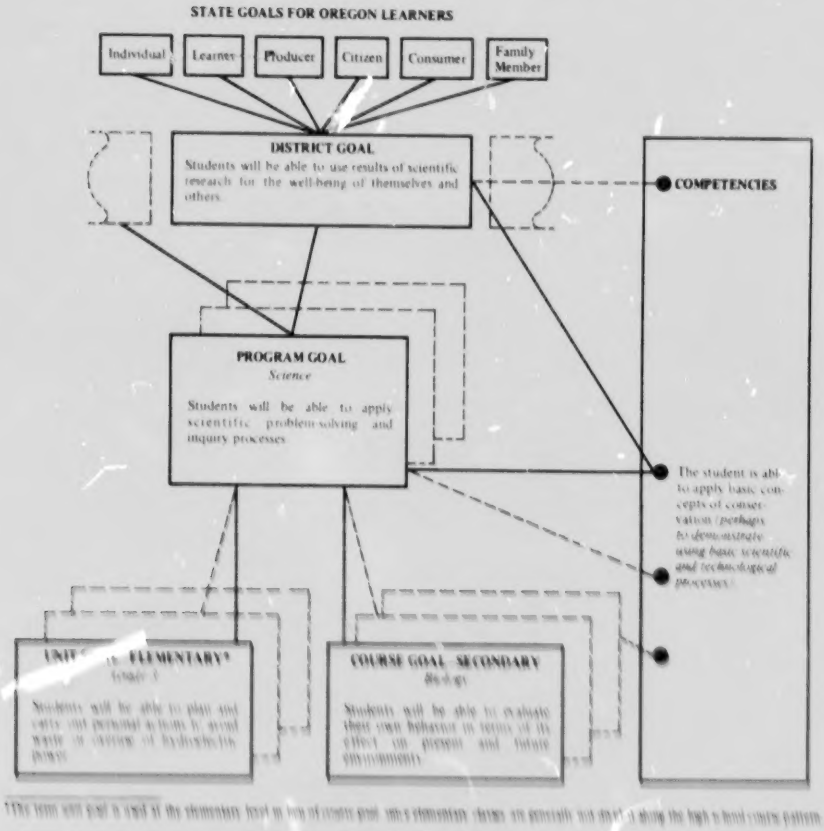
COMPETENCY in Oregon, as probably across the nation, means being *capable, fit*. For students, it means having demonstrated they can likely **APPLY** outside school what they've already learned in or out of school. A competency in Oregon is merely a local statement fixed as proof **ALL** students will likely be able to do tomorrow outside school something the community has agreed is worth doing. It is a local statement calling for **APPLYING** skills and information **ACQUIRED** from probably several courses (not just one[*]) . . . or from perhaps no courses at all. It is a local statement **ALL** students must demonstrate. If only **SOME** must—say, only those who take Biology I—the statement is **NOT** a competency in Oregon. Waivers aside, **ALL** students must demonstrate **ALL** competencies.

Viewed, then, as two separate but related designs, goals and competencies may look like this:

[*] To do otherwise may mean massive record-keeping chores for questionably narrow or shallow competencies.



For example, in science:


STATE GOALS FOR OREGON LEARNERS
Individual
Learner
Producer
Citizen
Consumer
Family Member
DISTRICT GOAL
Students will be able to use results of scientific research for the well-being of themselves and others.
COMPETENCIES
PROGRAM GOAL
Science
Students will be able to apply scientific problem-solving and inquiry processes
The student is able to apply basic concepts of conservation (perhaps to demonstrate using basic scientific and technological processes)
COURSE GOAL - SECONDARY
Students will be able to evaluate their own behavior in terms of its effect on present and future environments

The system of goals and competencies just described is designed to help the teacher and program specialist plan their own science program. It promotes a framework for planning that may be shared by all those doing similar planning. It helps in planning for individual student goals and interests, to be done within the limits of available resources. It should not be used to limit what is planned. Rather it should be used as a starting place.[1]

[1] For more information on goal-based planning, see Oregon Department of Education publications *Elementary Synopsis: An Aid for Oregon Schools, Part II, Science* (1977), *Planning the Education of Oregon Students: Setting Goals* (1975), *Writing District Program Goals and Course Goals* (1977) and *Measuring Performance: Testing Competencies through Observation and Judgment* (1977).

The Framework for Science Programs

In Oregon, three complementary publications unfold goal-based planning for science programs. The *Elementary-Secondary Guide for Oregon Schools: Part I* requires K-12 science curriculum (pages 8-9). The *Elementary-Secondary Guide for Oregon Schools: Part II* suggests ways to balance curriculum alternatives (pages 7-13), explains goal-based planning (pages 17-30) and suggests eight goals for science with "seven dimensions" (pages 69-70). This *Framework for Science Programs* revises the eight goals and seven dimensions into a new seven suggested program goals. These new goals become the framework for science programs.

Each goal has a keyword: CONCEPTS, PROCESSES, SKILLS, INTERESTS, VALUES, INTERACTIONS, CHARACTERISTICS. Each keyword has several dimensions: 29 concepts, 15 processes, 6 skills, 6 interests, 6 values, 4 interactions, 8 characteristics.

requires K-12 science curriculum

suggests 8 goals & 7 dimensions

revises 8 goals & 7 dimensions
into
7 new goals with several dimensions

29 CONCEPTS 15 PROCESSES 6 SKILLS 6 INTERESTS 6 VALUES 4 INTERACTIONS 8 CHARACTERISTICS

Course goals teachers may write might then feed any one or combination of these seven suggested program goals below. Course goals might build upon the dimensions.

I Students will know scientific CONCEPTS and related theories, laws, assumptions and facts:

1 CAUSE-EFFECT correlatives enabling predictions to be made
2 CHANGE becoming different
3 CYCLE pattern in which events or conditions seem to be repeated at regular intervals
4 ENERGY-MATTER mutually convertible equivalents
5 ENTROPY a measure of the degree of disorder in a substance or a system; entropy increases and available energy decreases in a closed system, as the universe

6 EQUILIBRIUM a state of balance or equality between opposing forces
7 EVOLUTION an unfolding of slow changes to explain how something got to be the way it is or what it might become
8 FIELD a space in which one thing influences another, often without direct physical contact
9 FORCE a push or a pull
10 FUNDAMENTAL ENTITIES units of structure and function useful in explaining phenomena
11 GRADIENT intensity varying in a more or less regular pattern
12 INTERACTION two or more things influencing each other
13 INVARIANCE a characteristic which stays constant even though other characteristics may change
14 MODEL a representation having explanatory value
15 ORDER viewing nature as systematic or believing a system may be imposed on nature
16 ORGANISM a system living or once living characterized by the processes of life
17 PERCEPTION mental apprehension by means of the senses
18 PROBABILITY appearing reasonable on the basis of evidence or logic but neither certain nor proved
19 POPULATION a set of fundamental entities having common characteristics
20 QUANTIFICATION expressing measurable amounts
21 REPLICATION repetition under controlled conditions to get the same results
22 RESONANCE action within one system causing similar action within another system
23 SCALE a set of relative values for measuring
24 SIGNIFICANCE differences too great to be reasonably attributed to chance
25 SYMMETRY similarity of form on either side of a dividing line
26 SYSTEM an arrangement of things related to make a whole
27 THEORY a belief proposed as a basis for action
28 TIME-SPACE interrelations between duration and distance
29 VALIDATION obtaining similar results by two or more different methods

II Students will be able to apply scientific problem-solving and inquiry PROCESSES.

1 CLASSIFYING systematically imposing order on data
2 COMMUNICATING exchanging information
3 CONTROLLING VARIABLES identifying and managing factors that may influence an experiment
4 DEFINING OPERATIONALLY describing what works
5 DESIGNING EXPERIMENTS planning data-gathering operations to test hypotheses or answer questions
6 FORMULATING MODELS devising representations to perform as the real things
7 HYPOTHESIZING tentatively accepting an explanation as basis for further investigation
8 INFERRING concluding from known facts or evidence
9 INTERPRETING DATA finding patterns or meanings not immediately apparent
10 MEASURING using instruments to determine value
11 OBSERVING using the senses to obtain information
12 PREDICTING foretelling from previous information
13 QUESTIONING raising uncertainty
14 USING NUMBERS expressing ideas, observations and relationships in figures, often as complements to using words
15 RELATING TIME-SPACE describing how duration affects distance and vice versa

III Students will be able to apply hand SKILLS safely.

1 MEASURING using, e.g., thermometers, balances
2 CONSTRUCTING shaping, e.g., glass with flame or operating power tools
3 HANDLING MATERIALS e.g., chemicals, flammables
4 MAINTAINING MATERIALS e.g., microscopes, voltmeters
5 USING VOCATIONAL MATERIALS e.g., graphs, computer printouts
6 EQUIPPING FOR AVOCATIONS e.g., cameras, aquariums

IV Students will be able to satisfy their INTERESTS in science.

1 GETTING CONFIDENCE participating in and understanding scientific things at students' own levels of sophistication

2 LEARNING FROM MANY SOURCES reading (books, periodicals, newspapers), watching (nature, television), visiting (museums, exhibits)
3 WANTING AND GIVING SCIENTIFIC EXPLANATIONS preferring systematic and exact explanations to nonscientific ones, if the former at appropriate levels of sophistication
4 FINDING AVOCATIONS learning that hobbies such as shell collecting, photography, bird watching can be rewarding
5 EXPLORING VOCATIONS considering science-related careers
6 PERCEIVING HEROINES AND HEROES recognizing today's scientific contributions while understanding judgment of them may come tomorrow

V Students will be able to apply VALUES that underlie science.

1 KNOWING AND UNDERSTANDING directing inquiry toward knowledge as a worthy investment of time and other resources
2 QUESTIONING ALL THINGS believing even truths may be challenged
3 SEARCHING FOR DATA AND MEANING acquiring and ordering data because they are bases for theories used to explain phenomena
4 DEMANDING VERIFICATION urging data be validated and made public
5 RESPECTING LOGIC insisting on valid induction and deduction as bases for action
6 CONSIDERING CONSEQUENCES continuing or aborting actions based on results

VI Students will be able to describe INTERACTIONS between science and society.

1 SOCIETY'S INFLUENCE society's needs, wants and money affect what science investigates and technology develops; society--including scientists and technologists--ultimately determines how science is applied
2 SCIENCE'S INFLUENCE scientists open-mindedly and steadfastly must investigate what society may *think* irrelevant or trivial, though it may take time for society to realize benefits; even when realized, some benefits may have undesirable side effects, trade-offs
3 MUTUAL UNDERSTANDING scientists, technologists and educators owe the public clear and timely information; the public in turn need to pay attention, to question and to realize scientists may disagree because they interpret data differently
4 LIMITATIONS OF SCIENCE science cannot solve all society's problems; solutions may be impossible, some may defy scientific methods, none can be legislated, bought or guaranteed

VII Students will be able to describe CHARACTERISTICS of science.

1 TENTATIVE subject to change, not truth in an absolute and final sense
2 PUBLIC other individuals could arrive at similar conclusions when confronted with the same evidence
3 REPLICABLE based on evidence which could be obtained by other investigators working in different places at different times given similar conditions
4 PROBABILISTIC permits reasonable but not certain predictions and explanations
5 HUMANISTIC creatively imposes order on nature or finds patterns in nature
6 HISTORIC past knowledge should be viewed in historical context, not degraded on the basis of present knowledge
7 EMPIRICAL tests hypotheses by experiment and observation after collecting data exactly, systematically, objectively
8 HOLISTIC specialized sciences contribute to an overall conceptual scheme internally consistent; differences are of degree, not kind

The Framework in Perspective

How might all these goals and dimensions give balance to a K-12 science program? When might given dimensions be introduced?

Below in the table is a *SUGGESTED* answer.

I CONCEPTS	K-3	4-6	7-9	10-12
1 cause-effect		X	X	X
2 change	X	X	X	X
3 cycle	X	X	X	X
4 energy-matter	X	X	X	X
5 entropy				X
6 equilibrium		X	X	X
7 evolution		X	X	X
8 field			X	X
9 force		X	X	X
10 fundamental entities		X	X	X
11 gradient			X	X
12 interaction		X	X	X
13 invariance			X	X
14 model			X	X
15 order		X	X	X
16 organism	X	X	X	X
17 perception			X	X
18 probability			X	X
19 population	X	X	X	X
20 quantification		X	X	X
21 replication			X	X
22 resonance				X
23 scale			X	X
24 significance			X	X
25 symmetry			X	X
26 system		X	X	X
27 theory		X	X	X
28 time-space			X	X
29 validation			X	X
II PROCESSES				
1 classifying	X	X	X	X
2 communicating	X	X	X	X
3 controlling variables		X	X	X
4 defining operationally				X
5 designing experiments		X	X	X
6 formulating models			X	X
7 hypothesizing			X	X
8 inferring		X	X	X
9 interpreting data	X	X	X	X
10 measuring	X	X	X	X
11 observing	X	X	X	X
12 predicting		X	X	X

	K-3	4-6	7-9	10-12
13 questioning	X	X	X	X
14 using numbers	X	X	X	X
15 relating time-space			X	X
III SKILLS				
1 measuring	X	X	X	X
2 constructing			X	X
3 handling materials	X	X	X	X
4 maintaining materials				X
5 using career materials		X	X	X
6 equipping for avocations	X	X	X	X
IV INTERESTS				
1 getting confidence	X	X	X	X
2 learning from many sources	X	X	X	X
3 wanting and giving scientific explanations		X	X	X
4 finding avocations	X	X	X	X
5 exploring vocations			X	X
6 perceiving heroines and heroes		X	X	X
V VALUES				
1 knowing and understanding	X	X	X	X
2 questioning all things	X	X	X	X
3 searching for data and meaning		X	X	X
4 demanding verification		X	X	X
5 respecting logic			X	X
6 considering consequences		X	X	X
VI INTERACTIONS				
1 society's influence		X		X
2 science's influence		X		X
3 mutual understanding			X	X
4 limitations of science		X	X	X
VII CHARACTERISTICS				
1 tentative	X	X	X	X
2 public		X	X	X
3 replicable		X	X	X
4 probabilistic			X	X
5 humanistic	X	X	X	X
6 historic		X	X	X
7 empirical	X	X	X	X
8 holistic			X	X

The Framework at Work

Activities this framework supports may be similarly grouped K-3, 4-6, 7-9, 10-12. In the next chapter, 12 sample activities illustrate how science instructors might direct these goals and dimensions toward science instruction itself—one for each level in earth science, one for each in life science, one for each in physical science. Another 20 activities illustrate how science instructors might integrate science instruction with other special interests: prekindergarten, reading, math, career education, handicapped.

Deductive ties may be imagined from state goals to course goals. Inductive ties may be imagined from course goals to state goals. How these ties may evolve into activities for selected grade groupings will be illustrated in this format . . .

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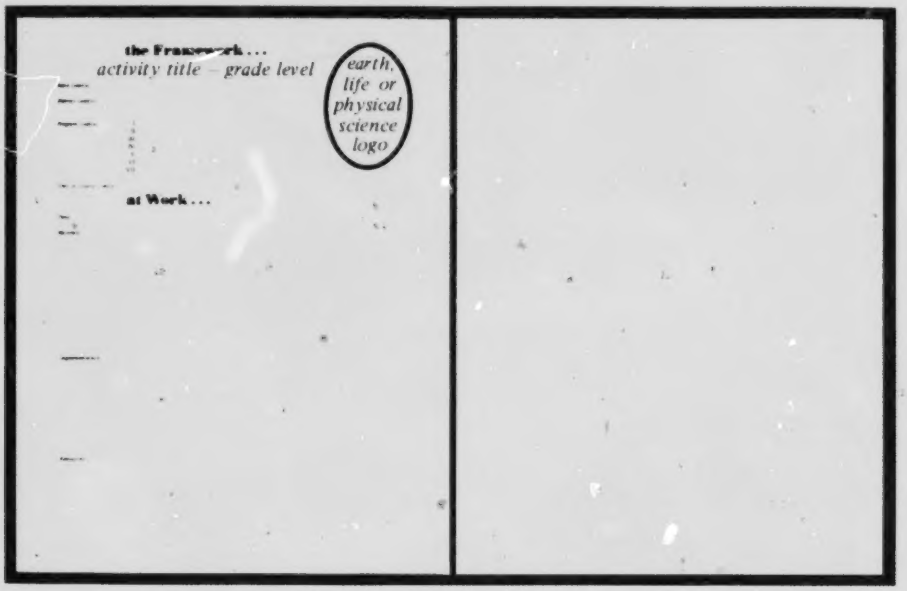

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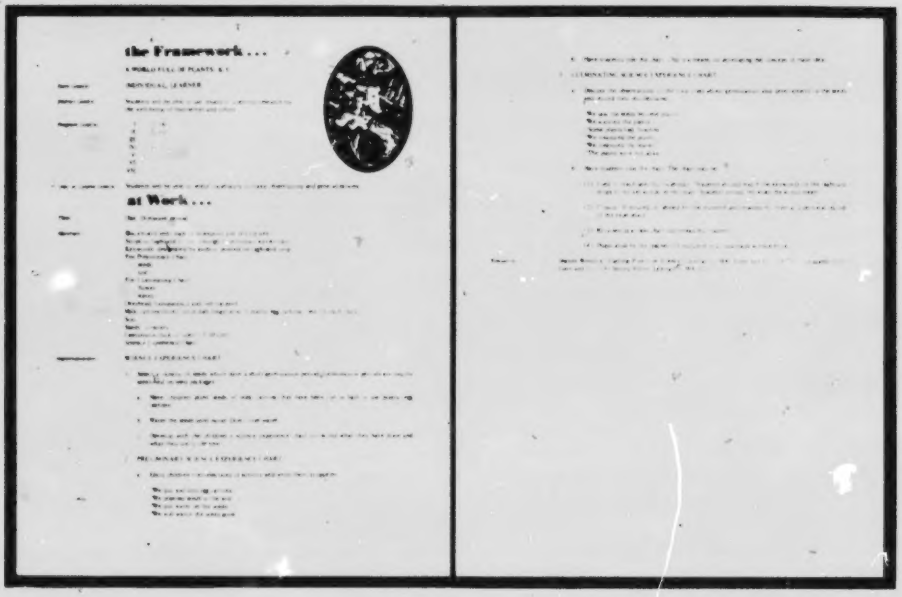

Earth science activities will be identified by or its partial . Life science by or .

Physical science by or .

Quality local science programs should assure effective contribution of science instruction to the six State Goals for Oregon Learners. They should also assure well-prepared staff, adequate facilities, and the best use of human, institutional and materials resources in the community.

Local district staff might create a checklist to evaluate the quality of its own science program. Does the local science program, for example, assure:

- ____ local program goals from cooperative planning between staff and interested members of the community?
- ____ presentations by competent staff:
  - ____ with sound knowledge of science and its relation to human affairs?
  - ____ with understanding of the nature of youth–their needs and interests, how they learn, how they develop?
  - ____ with skill in planning, managing and communicating learning activities?
- ____ students frequently *use* the skills associated with the processes of scientific inquiry?
- ____ science instruction is met through a continuous K-12 program–student-centered, sequential, organized in a context of human values and social dilemmas?
- ____ a wide range of facilities and resources to meet the varying needs of students?
- ____ extensive opportunities for first-hand experiences with the materials and phenomena of nature in a variety of settings?
- ____ extensive use of local resources?
- ____ assessment of student progress toward desirable goals, and periodic evaluation of the program and its goals, staff, methodologies and resources?
- ____ adequate financial resources for staff to plan and execute a complete program of science education?
- ____ a reciprocal relationship with other curriculum areas, contributing to them and benefiting from them?
- ____ energy and environmental education that interrelates natural phenomena, energy and environmental influences, economic considerations, science and technology, and their social implications?
- ____ students can *like* science in general and independent investigation in particular?
- ____ a sound rationale for organizing flexible content and learning experiences?
- ____ opportunities for students to work individually and as members of various sized groups?
- ____ opportunities for students to become familiar with vocations and avocations in science and allied fields?
- ____ a hazard-free learning environment through exemplary safety instruction procedures and practices?

SAMPLE SCIENCE ACTIVITIES

For more than two decades a series of social and legal developments has resulted in pressures on public schools to spread more equitably among all youth the benefits of free public education. The *Brown* decision by the Supreme Court in 1954 and the Civil Rights movement of the 1960's were key developments. The general public and the teaching profession are familiar with such terms as "equal educational opportunity," "the rights of the handicapped," "bilingual and bicultural education," "women's rights," "education for the disadvantaged," "affirmative action" and the "right to read."

Laws now support these movements, and schools are not exempt. The staff of every school must seek ways to accommodate demands on its programs.

Moreover, other problems face our society: the energy crisis, resource exhaustion, environmental degradation, food shortages, population growth. Government units such as the Environmental Protection Agency and the Energy Research and Development Agency represent public interests, but they do not directly influence curriculum change. The general force of public opinion serves as the motivating factor for school practice. Perceptive science teachers have anticipated these social problems, and some are beginning to do something about them. Many, for example, try to introduce activities to encourage energy conservation. Many encourage other environmental investigations: trade-offs, say, in land use or waste disposal or industrial growth and pollution. Always the search is for workable and equitable relationships with nature.

This *Framework for Science Programs* tries to address these and other movements and problems. It looks at science instruction through goal-based planning. In this chapter, the first 12 activities treat science instruction itself under "Science Special Interests" — four in earth science (one each for K-3, 4-6, 7-9, 10-12), four in life science and four in physical science. The next 20 activities under "Other Special Interests" similarly treat science instruction as a reciprocal special interest — science as it interacts with prekindergarten, reading, math, career education, handicapped.

The illustration below shows the distribution of the sample activities.

Science Special Interests	preK	K-3	4-6	7-9	10-12
		X	X	X	X
		X	X	X	X
		X	X	X	X
Other Special Interests					
prekindergarten					
reading					
math					
career education					
handicapped					

Science Special Interests

Air Takes Up Room – K-3	15	
Windmills, Gliders and Kites – 4-6	16	
Water Cycle – 7-9	18	
Sea Water and Fresh Water – 10-12	19	
"Inventing" the Concept *Habitat* – K-3	21	
Taking an Animal Count – 4-6	23	
Stream Study I – 7-9	24	
Stream Study II – 10-12	26	
Using My Senses – K-3	28	
Where Are Sounds Loudest? – 4-6	31	
How Does It Happen in Your Town? – 7-9	32	
Determining the Formula for an Unknown Compound – 10-12	33	

the Framework . . .

AIR TAKES UP ROOM–K-3

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	2
II	10, 11
III	1
IV	
V	1, 2
VI	
VII	7

Unit or Course Goal(s) Students will be able to explain why things need air and which items must have air in order to be useful.

at Work . . .

Time Two class periods

Materials

Football or balloon
Balance scale
Hand pump or air tank

Implementation

1. Begin the activity by having the students use their senses of sight, hearing and touch to detect the presence of air.
2. Ask them to describe what they feel, hear and see with other simple experiments. Let them decide on what experiments they want to do.
3. Have the students determine what indicates that air is present.
4. Place a deflated football or balloon on the balance scale.
5. Have the students read the mass. Record their findings on either the blackboard, overhead projector sheet or chart.
6. Fill the football or balloon with air from the air tank or by using the hand pump.
7. Again, determine the mass of the football or balloon. Record the mass.
8. Extension:

   This activity lends itself to further math activities.

Resources Oklahoma State Department of Education, *OKLAHOMA AEROSPACE* (Oklahoma City: Oklahoma State Department of Education, 1976)

the Framework . . .

WINDMILLS, GLIDERS AND KITES--4-6

State Goal(s) INDIVIDUAL, LEARNER, CONSUMER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 12
II	3, 4, 12
III	1, 2, 3
IV	1, 2
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to compare wind as a source of usable energy with other more commonly used forms.

Students will be able to relate experiences to the technical problems of making efficient use of a new source of energy such as the wind.

at Work . . .

Time Eighteen 30-minute periods

Materials Used papers to make glider models.

Implementation Instructions for project available from *Energy and Conservation Education* . . . (see *Resources* below).

1. Introduce the idea of using sources other than water to produce energy. List the students' ideas on the board and discuss them.

2. Tell the class that wind power should be one of the possibilities listed and that the class project will involve the study of wind power as an energy source.

3. Discuss the various uses of wind power. Some examples might include: windmills, gliders, kites, etc.

4. The students should be able to tell some of the advantages and disadvantages of using wind power. (Activities 5 and 6 which follow should broaden their knowledge in this area.)

   Examples of advantages and disadvantages of wind power:

Advantages	Disadvantages
(1) Clean energy source	(1) Need at least 16 km/h wind
(2) Unlimited supply	(2) Wind speed varies greatly over short distances
(3) Cheap	(3) When using a windmill, it must be positioned so that the wind source is not blocked.

5. Show and discuss available films on wind power.

6. Have the class research and become involved in projects on how wind power might be used. As a follow-up of Activity 3 above, some possible projects related to wind power are listed here:

   a. Windmills

      (1) Research the construction and use of windmills. Through their research, students should

become aware of the fact that windmills are used for various purposes (e.g., windmills can be used to generate electricity or to grind flour). Students could diagram and label windmills and their various purposes for a bulletin board display.

(2) Show available films and filmstrips.

(3) If possible, visit the site of a windmill.

(4) Build a prototype of a windmill.

Plans for this project are available in *Energy and Conservation Education . . .* (see *Resources* below). (During testing of the windmill, use an electric fan to supply the "wind" if it is not windy enough out-of-doors.)

b. Gliders

(1) Have the students do research on gliders.

(2) Show available films and filmstrips.

(3) Have the students design and construct their own model gliders out of paper. (Paper could be obtained by using old assignment papers, old math papers, etc.)

(4) Have a class contest out on the playground to see whose glider can stay up the longest and whose can travel the farthest. Why does one stay up longer or travel further than another?

c. Kites

(1) Study the history of kites.

(2) Have interested students make and fly their own kites.

Extra Credit

Have the students think of new or different ways in which wind power could be "harnessed." Have the students make designs of their ideas and build prototypes if possible.

8. Suggested Career Awareness Activity

Invite a person who has had experience with planes to explain wind as a source of energy when flying. Have the students interview him/her in regard to what it is like to be a pilot.

Resources

Energy and Man's Environment, Inc., *Energy and Conservation Education: Activities for the Classroom, Grades 4-6* (Portland, OR: Energy and Man's Environment, Inc., 1977), Activity 7 . . . available from Energy and Man's Environment, Inc., 0224 SW Hamilton, Portland, OR 97201

the Framework . . .

WATER CYCLE–7-9

State Goal(s) — INDIVIDUAL LEARNER

District Goal(s) — Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 3
II	8, 11
III	3
IV	
V	
VI	
VII	

Unit or Course Goal(s) — Students will be able to demonstrate and explain the water cycle.

at Work . . .

Time — Two to three 50-minute periods

Materials

Celery (leafy)	Watch glass
Knife	Sand (soil)
Jar	Glass (plastic wrap)
Food coloring	Sunlamp (150-watt)
Aquarium	Tape
Beaker (250 ml)	Heat source

Implementation

1. Split a piece of leafy celery part way up the stalk.
   a. Trim the bottom of the celery stalk under water to prevent wilting.
   b. Quickly transfer the stalk into a jar containing dyed water.
   c. Place the jar with celery into a terrarium or aquarium and seal airtight with glass or plastic wrap.
   d. After several minutes, observe how high the dye has risen.
   e. What did you notice happening on the inside of the glass? The process by which plants release water vapor into the atmosphere is transpiration.
2. Boil 20 ml of water in a 250 ml beaker with a watch glass (or piece of glass) on top.
   a. What do you see on the underside of the watch glass after the water has boiled several minutes?
   b. Explain what you see.
3. Fill one side of an aquarium with sand or soil (representing land).
   a. Fill the other side with water; or, place a large can containing water inside.
   b. Tightly cover and tape a piece of glass on top of the aquarium.
   c. Place a 150-watt sunlamp directly over the half of the aquarium containing water.
   d. What starts to happen to the water level in the pan after several hours?
   e. Where does condensation (precipitation) occur?
   f. Why?
   g. What happens when clouds of moist air cool over land?
4. Draw and label a complete diagram of the water cycle.

Resources — *A Handbook of Environmental Encounters* (Salem: Oregon Department of Education, 1973)

the Framework . . .

SEA WATER AND FRESH WATER–10-12

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 2
II	10, 11, 12
III	1, 3
IV	1, 3
V	1
VI	
VII	3, 7

Unit or Course Goal(s) Students will be able to determine the differences between fresh water and sea water.

at Work . . .

Time One 55-minute period

Materials

Tap water
Sea water (or salt water with salinity 35 parts per 1000)
Evaporating dishes or small beakers
Tripod
Bunson burner
Graduated cylinder
Hydrometer
Small test tubes
Liquid soap
Silver nitrate solution

Implementation

1. Mineral Content
   a. Pour about 10 ml of fresh tap water into an evaporating dish or small beaker.
   b. Pour an equal amount of sea water into a second dish.
   c. Heat both dishes until all the water evaporates. (Use a *very* small flame, especially as the quantities become small, to avoid splattering.)
   d. Remove the flame as soon as evaporation is complete. *Caution:* BE CAREFUL NOT TO HANDLE THE DISHES UNTIL THEY HAVE COOLED.
   e. Ask the question: What residue, if any, do you find in each dish? Account for the difference.
2. Specific Gravity
   a. Use the hydrometer to compare the specific gravities of fresh tap water and sea water.
   b. Observe and record the readings of the hydrometer.
   c. Account for any differences between the readings. Explain.
3. Chemical Behavior
   a. Presence of dissolved chlorides
      (1) Use a solution of silver nitrate to test for dissolved chlorides. When a few drops of silver nitrate solution are added to another solution, a white precipitate (silver chloride) is formed if dissolved chlorides are present.

(2) In small test tubes, test both the fresh water and the salt water for the presence of dissolved chlorides. Use only a few drops of silver nitrate solution. *Caution:* BE CAREFUL NOT TO GET SILVER NITRATE ON YOUR SKIN.

(3) Describe the results. Account for any differences.

b. Reaction with Soap

(1) Half fill one small test tube with fresh water and a second small test tube with sea water.

(2) Add two drops of liquid soap to each.

(3) Shake well.

(4) Observe the degree to which soap suds form.

(5) Account for any differences.

(6) Add two more drops of soap to each test tube.

(7) Shake well.

(8) Explain any differences from the reaction to the addition of the first two drops of soap.

4. Summary

List four respects in which sea water differs from fresh water.

Resources

Samuel N. Namowitz, *Earth Science Activities*, teacher's annotated edition (Burlingame, CA: American Book Company, 1978) . . . available from American Book Company, 1818 Gilbreth Road, Burlingame, CA 94010

the Framework . . .

"INVENTING" THE CONCEPT *HABITAT*–K-3

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	16, 19
II	2, 11
III	3
IV	3
V	1
VI	
VII	

Unit or Course Goal(s) Students will be able to invent the concept *habitat*.

at Work . . .

Time Several weeks

Materials

Habitat board (2 cm x 25 cm x 25 cm)
6-litre aquarium (containing aged tap water, green algae, hornwort, duckweed, dwarf sagittaria, snails, guppies, sand, plant minerals)
Sand (one kg)
Dip net (course mesh)

Implementation

1. Advance Preparation: Prepare six litres of aged tap water and rinse one kg of sand. You should have set out a habitat board two or three weeks ago.

2. Introduce the concept *habitat*

   a. Invention

   (1) Standing in front of the class, set up the aquarium by pouring the rinsed sand and aged tap water into an empty container. After the sand has settled, tell the children that a *habitat* is the place where a plant or animal lives. The aquarium is one kind of habitat.

   (2) Write the word *habitat* on the chalkboard.

   - Ask the children what plants and animals in the room could live in the new aquarium habitat.
   - Transfer a sample of each organism they suggest to the new container.
   - After the transfer has been completed, ask the children to describe the new habitat.
   - Then ask them why they did not suggest adding pumpkin plants, peas, or any other plants that are growing in the room.
   - Accept all answers. The habitat concept will become more meaningful as the children discover other habitats on their own.
   - Ask children if they can think of any outdoor habitats that are like the aquarium.
   - They may suggest ditches, ponds, lakes, and streams. If they do not, you should mention them, or perhaps take a field trip.
   - Remind the children of one or two plants or animals they observed on the field trip. Were their habitats different from the aquarium? In what way?
   - Ask the children to name other organisms that have habitats different from or similar to the aquarium.

(3) Return the organisms to the class aquarium.

b. Discovery

Take the class to visit the habitat board.

- Lift the board and let the children observe the organisms beneath it.
- The kinds of organisms living in the relatively dark, damp habitat beneath the board will depend on the locality and time of year.
- Ask the children to describe the conditions under the board (dark, damp, cool).
- Ask them if they can think of other places where they might find the same kinds of organisms.
- Replace the board. Return every few days until the children's interest slackens.

c. Record

(1) Have students list or draw the organisms they found under the habitat board.

(2) Ask the students to name other habitats and suggest they look for some on the way to and from school.

d. Optional Activities

(1) What do habitats look like?

(2) Can organisms live outside their habitats?

(3) Why are some plants grown in greenhouses rather than outdoors?

Resources

Herbert D. Thier, et al, *Organisms (Level 1) Teachers Guide* (Chicago: Rand McNally and Company, 1978) . . . available from Rand McNally and Company, PO Box 7600, Chicago, IL 60680

the Framework . . .

TAKING AN ANIMAL COUNT–4-6

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	16, 19, 26
II	2, 5, 8, 9, 10, 11, 12
III	1, 3, 6
IV	1
V	1, 3
VI	
VII	

Unit or Course Goal(s) Students will be able to take an animal count or *census*.

at Work . . .

Time One to two 30-minute periods

Materials
Record paper and pencil
Metre stick
Magnifier
Trowel or other digging instrument
Flashlight

Implementation

1. Form small groups (3-4 students) from class.
2. Have each group investigate a different area, e.g., vacant lot, cellar, forest.
3. Record the number of vertebrates found in each area. Include people, dogs, lizards, etc.
4. *Caution*: DO NOT HANDLE ANIMALS. Just list them.
5. Suggestion: Write down all groups that are suggested. Add a group labeled "Other." Each time an animal is found make a mark opposite the group to which it belongs.
6. Then, with pencil and paper, flashlight, magnifier and trowel, begin to hunt for invertebrates; e.g., outside of buildings, under windowsills, bottoms of rocks and bricks, behind downspouts, under tree bark, under paper, in bushes, on leaves and even in old bird nests. Look carefully.
7. Then examine one square metre (m^2) of soil surface. Use magnifier. Dig down in the soil.
8. Conclude the census.
9. Add up all invertebrates that are found.
10. Question: How does this compare with the number of vertebrates found?
11. Remind students that they probably saw only a small portion of the invertebrates around them.
12. Ask students to share their thoughts about how many more invertebrates there must be in a large field, a forest, the sea, etc.

Resources Verne N. Rockcastle, et al, *Stem Science*, level 5 program (Menlo Park, CA: Addison-Wesley Publishing Company, Inc., 1978) . . . available from Addison-Wesley Publishing Company, Inc., 2725 Sand Hill Road, Menlo Park, CA 94025

the Framework . . .

STREAM STUDY I–7-9

State Goal(s) INDIVIDUAL, LEARNER, CITIZEN

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	12, 16, 19
II	5, 9, 10, 12
III	
IV	
V	
VI	
VII	4

Unit or Course Goal(s) Students will be able to conduct a stream survey.

at Work . . .

Time Six 50-minute periods

Materials

Field sheets or notebooks
Hand lenses
Microscopes
Plant and animal identification books
Porcelain pans
Medicine droppers

Implementation

1. Problem: Does the abundance of life vary in different regions of a stream?

   This study will consist of a survey of a stream to note physical factors which will define the above regions and collection of samples to determine abundance of organisms in these regions.

   a. Day one:
      Locate the site on a map. Have students copy the section of the stream they are to study. Discuss the problem and possible problem-solving methods.

   b. Day two:
      At the study site have students note the physical factors such as stream flow, stream depth, stream velocity, and so forth. *Caution*: OBSERVE ALL WATER SAFETY PROCEDURES.

      When the physical factors are outlined, select study sites and assign student teams to areas for collection purposes.

   c. Day three:
      In the lab have students decide the type of collection materials they will need and how they will sample from the site. Care should be taken to make samples uniform and to make them in such a way that they will not do damage to the site. Students should also determine how they will record data.

   d. Day four:
      At each site collect and observe organisms in accord with agreed-on plans. Be careful not to interfere with other teams' sites and not to overhandle the organisms.

   e. Day five:
      Assemble data and prepare for team presentations.

f. Day six:
Team presentations of site data. Students continue work on individual reports to present their answer to the problem question.

2. Suggested follow-up activities:

a. Identify aquatic insects and relate to trout flies.

b. Search for signs of pollution.

c. Catalog the uses of the stream.

d. Search out historical facts concerning the stream.

Resources

William A. Andrews, *Freshwater Ecology* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972)

A Handbook of Environmental Encounters (Salem: Oregon Department of Education, 1973)

James G. Needham and Paul R. Needham, *A Guide to the Study of Freshwater Biology* (San Francisco: Holden-Day, Inc., 1962)

Robert W. Pennak, *Fresh-Water Invertebrates of the United States* (New York: The Roland Press Co., 1953)

the Framework . . .

STREAM STUDY II–10-12

State Goal(s) INDIVIDUAL, LEARNER, CITIZEN

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 6, 12
II	5, 9, 10, 12
III	
IV	
V	1
VI	
VII	7

Unit or Course Goal(s) Students will be able to determine the effects of an urban environment on a stream.

at Work . . .

Time Ten 50-minute periods

Materials

Field sheets or notebooks
Hand lens
Microscopes
Plant and animal identification books
Porcelain pans
Medicine droppers
Test kits (e.g., Hach, LaMotte)

Implementation

1. Problem: What effect does passing through an urban environment have on a stream?

   a. Day one:
   Pose problem and locate stream on a map. Various types of maps will give different information, so use a variety. Students should consult maps either (1) to choose site or (2) to locate the sites selected. Care should be taken to choose sites which are safe. *Caution*: OBSERVE ALL WATER SAFETY PROCEDURES.

   b. Day two to five:
   Begin practice of testing to determine physical factors. The following is a list of factors which are most easily done and which yield the most valuable information:

   (1) stream flow
   (2) volume, profile
   (3) temperature
   (4) color
   (5) turbidity
   (6) dissolved oxygen
   (7) free carbon dioxide
   (8) pH
   (9) alkalinity
   (10) total hardness
   (11) total suspended solids
   (12) total dissolved solids
   (13) nitrogen
   (14) ammonia
   (15) phosphorus

   c. Day six to eight:
   Begin practice of identifying indicator species which will be used in the study. A possible list might include:

   (1) aquatic insects
   (2) crustaceans
   (3) various worms
   (4) fishes and other vertebrates

d. Day seven:

Sampling five sites will require an entire day. A bus will be required and it will be helpful to have another adult to help with problems. Size of the city will also affect the amount of time needed. Site one will take a bit longer because different teams (dissolved oxygen and stream flow and volume, etc.) will have to be placed not to interfere with other teams. For example, a team which will disrupt the stream will have to be downstream from the other teams. At each site each team collects the data it is responsible for. Generally, the physical factors will take less time and fewer people so these teams should be smaller. The teacher will have to consider other circumstances relevant to the particular situation.

e. Days eight and nine:

All data should be collated and placed on one form which can be dittoed and returned to the student. The data should be considered as a group and then individual reports should be assembled which are directed at answering the problem question.

This plan is not meant to be complete, but to suggest the possibility for this type of study.

2. Suggested follow-up activities:

a. Search for signs of pollution and identify sources. Have students contact these sources to see if the situation can be corrected.

b. Search out historical facts concerning the site.

c. List the various towns and industries and other factors which will affect the quality of the water in this stream.

d. Contact the state division responsible for the quality of the stream or for the wildlife to see if the class can help improve the stream.

Resources

Andrews, William A., *Environmental Pollution* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1972)

Needham, James G. and Paul R. Needham, *A Guide to the Study of Fresh-Water Biology* (San Francisco: Holden-Day, Inc., 1962)

the Framework . . .

USING MY SENSES–K-3

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	
II	1, 8, 11, 12
III	3
IV	
V	1
VI	
VII	

Unit or Course Goal(s) Students will be able to identify sources of energy.

at Work . . .

Time Eleven 30-minute periods

Materials

Coal
Oil
Gasoline
Kerosene
Running water (faucet)
Wood
Food
Wind (fan, outside wind)
Sunlight (difficult to collect)
Butcher paper
Felt-tip markers
Handout 1 (see p. 30)

Implementation

1. Lessons 1 and 2:
   Sensory observations of basic energy sources:

   a. Have students examine and observe the various samples, comparing them for similarities and differences. Record student observations on a chart like the one shown in Handout 1.

   b. Show films *Energy and Power: A First Look* and *We Use Power.*

2. Lessons 3 and 4:
   Show film *Coal: A Source of Energy* and filmstrip *The Earth's Resources: Fuel Resources.*

   a. Discuss after the film the point that earth's resources are fossil fuels mined from within the earth.

   b. Have students make pictures showing the extraction of fossil fuels.

3. Lesson 5:
   Show film *The Forest Gives Us Wood.*

   a. Discuss after the film harvesting of wood as a source of energy.

   b. Have students make pictures depicting the lumbering industry and others showing how wood has been used as a fuel source.

4. Lessons 6 and 7:
   Water sources: (rivers, streams, the dams used with running water). Show film *Little Bluebird's Valley.*

   a. Discuss after the film water storage behind dams as an energy source.

   b. Show film *Powerline: Transportation of Energy.*

c. Draw pictures of water as an energy source. Point out that water power is often used in the form of electrical energy, after falling many metres and turning turbines to generate electricity.

5. Lesson 8:
Wind sources: Show film *Wind: A First Film.*

a. Discuss after the film man's past and present use of wind as an energy source.

b. Draw pictures showing uses of wind energy.

6. Lessons 9 and 10:
Food source: All animals, including human beings are dependent on food for energy to live. Without this energy, which comes directly or indirectly from plants, we would die. Without the sun, plants would die. Show the films *The Big Dinner Table* and *Food Energy and You.*

a. Discuss after the film the sun as the energy source for plants and plants as an energy source for man.

b. Ask how many students would be willing to miss several meals. Why? Point out to students our need for the energy from food to keep ourselves active and healthy.

c. Draw pictures showing food as an energy source.

7. Lesson 11:

a. Discuss our dependence on the sun for our existence.

b. Discuss the sun as a source of energy.

c. Ask the question, "What would happen if the sun vanished?"

d. Have students make drawings depicting the sun as an energy source.

8. Additional Activity:
Student pictures about energy sources might become part of a mural, made step-wise as each additional source is introduced and discussed. The mural and coloring book which accompanies this unit both illustrate these sources: coal strip mining, coal underground mining, oil well, forest, energy from wind, sun, falling water and food.

9. Suggested Career Awareness Activity:
Whenever possible in this set of activities point out the energy-related jobs people do. Help them find out what the jobs are like.

Handout 1

SOURCES OF ENERGY

A sample partially completed

OBSERVATION	coal	oil	gasoline	kerosene	water	wood	food	wind	sunlight
Seeing Color	black		brownish yellowish blueish		colorless		several		
Feeling Texture	rough	slick sticky etc.					several		hot warm
Mass Relative to Size									no mass
Solid Liquid		liquid					solid liquid		
Smell							sweet bitter		
Shape			no shape				several		no shape

Resources

Energy and Man's Environment, Inc., *Energy and Conservation Education: Activities for the Classroom, Grades 1-3* (Portland, OR: Energy and Man's Environment, Inc., 1977), Activity 4 . . . available from Energy and Man's Environment, Inc., 0224 SW Hamilton, Portland, OR 97201

the Framework . . .

WHERE ARE SOUNDS LOUDEST?–4-6

State Goal(s)

INDIVIDUAL, LEARNER

District Goal(s)

Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 2, 8
II	5, 10, 11, 12
III	1
IV	1, 3
V	3
VI	
VII	3, 4

Unit or Course Goal(s)

Students will be able to determine that sound energy is greatest near its source.

at Work . . .

Time

One to two 45-minute periods

Materials

Electric alarm clock (with a loud "buzz")
Piece of chalk
Tape recorder (battery-powered or 120-volt type with extension cord) and tape
Metric tape or stick

Implementation

1. Have students go to the gym or to a long hallway. Work in groups of two or three students.
2. Plug in alarm clock and place it against the wall of one end of the gym or hallway.
3. Use the metric measuring device (tape or stick) to measure a distance of 2 m straight out from the wall. Mark that distance with chalk.
4. Measure a distance of 4 m from the wall. Mark that spot with chalk. Repeat the measuring and marking until the 20 m distance from the wall is reached.
5. Turn on the alarm and let it buzz.
6. Place a tape recorder at the 2 m mark and record (be sure to always use the same volume level) the sound of the clock for about ten seconds. Turn off the recorder and move it to the 4 m mark. Record the sound for about ten seconds. Repeat this for each of the remaining marks you made on the floor.
7. Turn off the alarm. Listen to the tape recording.
8. Answer the following questions.
   Could you hear differences in the sound of the alarm clock on your tape recording? If so, where was it loudest? Where was it softest?
   Was there a place where you could no longer hear the buzz? If so, how far was it from the clock?
   What does this activity show about sound and distance?

Resources

George G. Mallinson, et al, *Science: Understanding Your Environment*, teacher's edition (Morristown, NJ: Silver Burdett Company, 1976) . . . available from Silver Burdett Company, 250 James Street, Morristown, NJ 07960

the Framework . . .

HOW DOES IT HAPPEN IN YOUR TOWN?–7-9

State Goal(s) **INDIVIDUAL, LEARNER, CITIZEN**

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	
II	2
III	
IV	2
V	1, 3
VI	
VII	

Unit or Course Goal(s) Students will be able to correspond with other students.

at Work . . .

Time Variable

Materials
Writing paper
Pen
Stamped, self-addressed envelope

Implementation

1. A group of four or more students will write for information regarding the sources of energy in specific areas of different states. Names of junior high students, to be contacted, may be known through existing contacts. Be sure to include a stamped, self-addressed envelope. Each student will select to whom he or she will write. Information requests will include:

   a. _____ are sources of energy used by industry in the area.

   b. _____ is the chief source of energy used by industry in the area.

   c. _____ is used for generating electricity in the area.

   d. _____ is the energy used by most homes for heating; _____, _____ are also used.

   e. Describe the public forms of transportation in the area.

   f. Is the public transportation system being used by more people than two years ago? Why?

   g. Is there successful organized effort to improve the impact people have on the environment? Describe some of these projects.

2. Be sure to express appreciation by mail to those responding to the requests.

3. Suggested Career Education Activity:
   Given the opportunity to contact persons from a variety of areas in the United States, the student will be able to discover the difference in employment opportunities which might occur in specific occupations of interest to the student.

Resources Energy and Man's Environment, Inc., *Energy and Conservation Education: Activities for the Classroom, Grades 7-9* (Portland, OR: Energy and Man's Environment, Inc., 1977), Activity 4 . . . available from Energy and Man's Environment, Inc., 0224 SW Hamilton, Portland, OR 97201

the Framework . . .

DETERMINING THE FORMULA FOR AN UNKNOWN COMPOUND–10-12

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 2, 6, 20
II	3, 5, 10, 14
III	1, 3
IV	1, 3
V	1, 3
VI	
VII	3, 7

Unit or Course Goal(s) Students will be able to determine the formula for an unknown compound.

at Work . . .

Time One 55-minute period

Materials

for each student:

Erlenmeyer flask (250 ml)
Beaker (1000 ml)
Graduated cylinder (100 ml)
Ringstand with buret clamp and ring
Burner
Square of aluminum foil (5 cm)
Pin
Balance
Thermometer
"Unknown" (5 ml)–this can be ethanol, methanol or other liquid which boils well below 100° C; the percentage composition of the "unknown" must be given to students prior to the experiment
Copper wire (8 cm of 18-24 gauge)

Implementation

Note: To help insure good results, the liquids used in this experiment must be *anhydrous.* While the liquids are on the storage shelf, use *anhydrous* $CaCl_2$ in the liquids (about 10 g/*l*) to take up any possible water. Replace with fresh $CaCl_2$ before student use.

	Percentage of Each Element		
Substance	*Carbon*	*Hydrogen*	*Oxygen*
ethanol	52.2	13.0	34.8
methanol	37.5	12.5	50.0
isopropyl alcohol	60.0	13.4	26.6
ethyl acetate	54.5	9.2	36.3
methyl ethyl ketone	66.6	11.2	22.2
triethylamine	71.1	15.0, plus 13.9% nitrogen	

Prelab Discussion

Discuss what is meant by percentage composition. Show students that, by knowing the percentage composition of a substance, one can derive the simplest formula (empirical formula) for the compound. Emphasize these steps:

1. Divide the percentage of the element by its atomic mass.

2. Divide each quotient by the smallest quotient to obtain a simple ratio of the number of atoms of each element in the compound.

3. Write the simplest formula according to the results of Step 2.

The only way to know whether the simplest formula is the true (molecular) formula is to determine the molecular mass of the compound. Then, the empirical mass of the simplest formula is divided into the molecular mass; the molecular formula is obtained by multiplying each subscript in the simplest formula by the number of times the molecular mass is greater than the empirical mass of the simplest formula.

Caution: HAVE STUDENTS BE CAREFUL WITH BOILING WATER. REMIND THEM OF THE PROPER TECHNIQUE FOR POURING HOT WATER.

Postlab Discussion

Student error will vary depending on the care with which the experiment is carried out. A careful student may have an error of 5-10%; a sloppy student's error may be as high as 20%. However, because the equipment and technique used in this experiment are relatively crude, an error of as much as 20% is acceptable. Results of this experiment are usually quite good if the foil seal is quite tight, if the hole in the foil is very tiny, and if the "unknown" is completely vaporized. Students also should take care to remove all water droplets from the outside surface of the flask and foil before finding the mass of the flask, foil, and wire at the end of the experiment.

Sample Data and Calculations (calculations based on methanol)

1. Barometric pressure: 90.23 kPa
2. Mass of flask, foil, and contents at end of experiment: 81.30 g
3. Mass of empty flask and foil: 81.00 g
4. Mass of unknown: 0.30 g
5. Volume of flask in ml: 267 ml
6. Volume of flask in litres: 0.267 *l*
7. Temperature of boiling water, observed: 96.0° C
8. Volume of vapor at S.T.P.: 0.176 *l* (original volume was 0.267 *l* at 96.0° C and 90.23 kPa)
9. Molecular mass of unknown compound:

$$0.30 \text{ g} \times \frac{22.4\ l}{0.176\ l} = 38 \text{ g}$$

10. Simplest formula of unknown compound: CH_4O
11. Molecular formula of unknown compound: CH_4O

Thirty-eight is near enough to the empirical mass, 32, to indicate that the simplest formula and molecular formula are the same.

Questions

1. Why was a tiny hole made in the aluminum foil cover to the flask?
2. What are the major sources of experimental error?
3. Why was the boiling temperature of the water used in correcting the vapor volume to S.T.P. instead of the room temperature?
4. Why did all the vapor of the unknown liquid not escape from the flask?
5. What was the pressure of the vapor after all of it that would escape had escaped?

Related Questions

1. During the heating of the water, many bubbles collected on the sides of the beaker. Where did they come from? What was their composition?
2. As the water began to boil, why did most of the bubbles seem to rise from the same points at the bottom of the beaker?

Resources

Elaine W. Ledbetter and Jay A. Young, *Laboratory Keys to Chemistry* (Menlo Park, CA: Addison-Wesley Publishing Company, Inc., 1977) . . . available from Addison-Wesley Publishing Company, Inc., 2725 Sand Hill Road, Menlo Park, CA 94025

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prekindergarten and science instruction

All educators should be concerned with prekindergarten education. Since children at ages three, four or five have already been greatly influenced by experiences before entering first grade, quality prekindergarten and kindergarten programs may be rewarding.

In formative years, awareness and understanding of scientific matters begin. As they respond to environmental stimuli, children learn from and about science. Prekindergarten and kindergarten programs can and should refine and enrich this awareness.

Young children may be taught virtually any concept if the presentation is in small, simple, logical steps. Science instruction not only fits into a prekindergarten or kindergarten program, it can provide the foundation for the rest of the school science curriculum. Formal education, which sometimes begins at the prekindergarten level, builds upon what children have already acquired and works toward developing citizens who have realized individual intellectual potential.

Science teachers especially can take advantage of prekindergarten experiences. Like scientists, young children are insatiably curious about the world around them, constantly questioning what, how, why. Their conclusions are tentative—subject to revision upon presentation of new evidence. Their lack of prejudice and their tolerance for new ideas present opportunities that science teachers, as well as prekindergarten teachers, may capitalize upon, sometimes learning right along with the children.

Prekindergarten and kindergarten teachers and science teachers share similar interests. Both want to

stimulate and satisfy curiosity
promote social and emotional development
help to build positive self-concepts
provide for vocabulary expansion
promote responsible behavior

Science teachers may additionally help children

sharpen skills for observation
develop skills for problem solving
develop skills for using tools and equipment
manipulate hands-on materials

Science teachers should act as advisers and resources for regular prekindergarten and kindergarten teachers. Such cooperation makes possible a meaningful science instruction program, one that accomplishes much more than merely acquainting children with factual content. Children learn how to learn.

Science activities should be planned for children to relate present to past learning experiences, to broaden frames of reference, to build vocabulary. Unless class learning is clearly connected to what children already know, continuity of learning will not be recognized. Children who only *hear* may forget. Children who only *see* may remember. Children who *do* may understand.

Science instruction at the prekindergarten and kindergarten levels provides excellent opportunities to build on learning and experience gained at an earlier stage, while preparing children for learning through and about science during the schooling years.

the Framework . . .

FLOAT AND SINK–preK

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	I
II	11
III	
IV	
V	
VI	
VII	7

Unit or Course Goal(s) Students will be able to determine if different objects float.

at Work . . .

Time One 20-minute period

Materials

Metal trays (2) for each group
Assorted objects for experimenting (clay, balsa wood, pumice, wax, rock, etc.)
Container for water (500 ml beaker)
Picture and word "sink" for one tray
Picture and word "float" for the other tray

Implementation

1. Fill water container.
2. Determine, through trial and error, whether each object sinks or floats when placed in water.
3. Place the object in the appropriate tray.
4. Mature children may enjoy recording their predictions and findings.
5. The children in the group should each have a turn trying different objects available for the experiment.

Resources

Mary Baratta Lorton, *Workjobs, Activity-Centered Learning for Early Childhood Education* (Menlo Park, CA: Addison-Wesley Publishing Co., 1972)

the Framework . . .

DO PLANTS NEED LIGHT?–preK

State Goal(s)

INDIVIDUAL, LEARNER

District Goal(s)

Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1
II	11
III	
IV	
V	
VI	
VII	7

Unit or Course Goal(s)

Students will know the effects of light on plant growth.

at Work . . .

Time

One 15-minute period (initially)

Materials

Containers (2) for each child (0.25 litre milk cartons)
Bean seeds (2) for each student
Soil (250 g) for each container

Implementation

1. Give each student two containers and two bean seeds that have been soaked.
2. Have the students fill the containers with soil, then plant and water the seeds.
3. Have each student place one container in a light spot, perhaps a window sill or table near a window.
4. Have each student place each remaining container in a dark place. Note: If no dark place is handy, the containers should be covered with dark butcher paper so no light will come through. Check the containers every two or three days for three weeks to see how they grow.

Resources

SCIIS, *Organisms* (Chicago: Rand McNally and Co., 1978) . . . available from Rand McNally and Co., PO Box 7600, Chicago, IL 60680

the Framework . . .

HOW MANY GREENS?–preK

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	19
II	11
III	
IV	1
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to classify.

at Work . . .

Time One 15-minute period

Materials An out-of-doors area where one can easily find plants of varying shades of green.

Implementation

1. Organize students in groups of 4-10.
2. Walk with students in an area where plants are found.
3. Instruct them to look for plants with different shades of green.
4. Locate five different plants, each with a shade of green different from the others.
5. Have students count the five and order them on their hand from lightest to darkest. *Do not pick the plants.* Leave them in their environment.

Resources Jack Wheatley and Herbert Coon, *100 Activities for Environmental Education* (Columbus, OH: The ERIC Center for Science, Mathematics, and Environmental Education, 1973) . . . available from ERIC/SMEAC Information Reference Center, The Ohio State University, College of Education, 1200 Chambers Road, 3rd Floor, Columbus, OH 43212

the Framework . . .

HOT AND COLD–preK

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	17
II	2, 11, 13
III	
IV	
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to describe feeling sensations.

at Work . . .

Time One 15-minute period

Materials
Three pans (large enough to place hand in when filled with water)
Ice cubes
Water from tap

Implementation

1. Fill three pans with water, each with a different temperature –e.g., to one add heated water, cool another by adding ice cubes, and leave the third pan at room temperature.
2. One student at a time places one hand in each of the pans marked Warm and Cold for one minute. Have student describe the feeling sensations.
3. Have the student place both hands in the pan of water labeled Room Temperature. Note the child's reaction and have the child describe the feeling found in each hand.
4. Raise some questions concerning temperature.
5. Allow the students to try variations of this investigation and have them relate them to experiences they may have had after playing in the snow and then entering a warm house. Do they recall sensation of the cold tap water feeling warm?

Resources John McGavack, Jr. and Donald P. LaSalle, *Guppies, Bubbles and Vibrating Objects* (New York: The John Day Co., 1969)

reading and science instruction

In September 1969, James E. Allen, Jr., the U.S. Commissioner of Education, declared that anyone lacking reading skills had been "denied a right—a right as fundamental as the right to life, liberty, and the pursuit of happiness—the right to read." He then proclaimed that "we should immediately set for ourselves the goal of assuring that by the end of the 1970's the right to read shall be a reality for all—that no one shall be leaving our schools without the skill and the desire necessary to read to the full limits of his capability."

Realizing such a goal demands the full cooperation of the educational community to a lifelong task. The content of reading each reader meets with a variety of skills. Teachers who utilize print to convey information thus must incorporate into their instruction reading strategies that will facilitate comprehension. Science teachers, whether they employ a laboratory or textbook approach, will expect students to deal with the written word. What teachers expect to be gained from written material will determine the responsibility they must assume in teaching those reading skills which will facilitate learning. When teachers assign reading as a learning aid, they are obligated to help students gain the greatest possible meaning.

Secondary science teachers must keep in mind that teaching reading in subject matter is not synonymous with teaching beginning reading. Science teachers are not expected to be remedial or corrective reading teachers. Rather, they are expected to develop the content area reading skills of all students, even the gifted.

Comprehending written discourse is a developmental skill that in the beginning stages of reading parallels word identifying skills. Because it is a cumulative experience, primary grade teachers must introduce reading strategies to create readiness for comprehension in the content areas. Thus preparation for reading science discourse must begin at the kindergarten level. An instructional reading strategy primary teachers often use successfully in teaching science is a language experience chart. Teachers can stimulate understanding of scientific processes by recording in a student's own words the student's own experience. What the student says about an experience becomes a written self-reminder and a building block for new experiences. The creation of science experience charts helps students label concepts, list facts, record observations and identify ideas, whether the knowledge was obtained through real or vicarious experiences. Fortunately, the use of the science experience chart as a source of reading material need not be limited to the primary grades.

In the intermediate grades, students make transitions from reading in reading programs to reading in various disciplines. The nature of subject matter materials, as well as differences among students, creates special problems which can only be met by deliberate and systematic attention to developing reading skills particular to the content. Fortunately, the comprehension and study skills found in the basic reading program are adaptable for instruction in the subject area. Teachers find the directed reading activity particularly useful for guiding reading in science.

By the time students reach junior high school, they usually no longer receive systematic instruction in reading. Still, they are expected to read in the subject matter. Science teachers can help students understand and use formats in content reading materials, e.g., headings, subheadings, side headings, italicized words, pictures, charts, graphs and summaries. SQ3R (Survey, Question, Read, Recite, Review)* makes maximum use of text format as a successful method to gain meaning from expository materials.

At the senior high school, students who elect to be in science courses are expected to be able to assimilate a variety of science resources. Students can be aided in their task by instruction in note taking, particularly in the construction of a reading study guide. A study guide can be developed as part of the question and recite steps of the SQ3R.

The science experience chart, directed reading activity, SQ3R, and the study guide are only four strategies among many which science teachers can use to teach students how to read science materials. Science teachers themselves should be best qualified to teach the vocabulary and concepts needed to read science materials.

*See Francis P. Robinson, *Effective Reading* (New York: Harper & Row Publishers, Inc., 1962).

the Framework . . .

A WORLD FULL OF PLANTS–K-3

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	2, 16
II	2, 11
III	
IV	1
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to select vocabulary to make observations and generalizations.

at Work . . .

Time One 20-minute period

Materials

Blackboard and chalk or newsprint and felt-tip pen
Strips of tagboard (5 cm–enough to introduce keywords)
Keywords, designated by author, printed on tagboard strip
For Preliminary Chart
- seeds
- soil

For Culminating Chart
- flower
- leaves

Overhead transparency and felt-tip pens
Milk cartons (litre) cut in half lengthwise or plastic egg cartons–one for each child
Soil
Seeds–a variety
Centimetre stick or ruler (15-30 cm)
Science Experience Chart

Implementation SCIENCE EXPERIENCE CHART

1. Select a variety of seeds which have a short germination period. Germination periods are usually identified on seed packages.

   a. Have children plant seeds in milk cartons that have been cut in half or use plastic egg cartons.

   b. Water the seeds until moist. *Don't over water.*

   c. Develop with the children a science experience chart to record what they have done and what they are to observe.

2. PRELIMINARY SCIENCE EXPERIENCE CHART

   a. Elicit children's recollections of activity and write them as spoken.

   "We put *soil* into egg cartons."
   "We planted *seeds* in the soil."
   "We put water on the seeds."
   "We will watch the seeds grow."

b. Have students title the chart. This is a means for developing the concept of main idea.

3. CULMINATING SCIENCE EXPERIENCE CHART

a. Discuss the observations of the total class about germination and development of the seeds and record their recollections.

"We saw the seeds become plants."
"We watered the plants."
"Some plants had flowers."
"We measured the plants."
"We measured the leaves."
"The plants were not alike."

b. Have students title the chart. The chart may be:

(1) Used to teach specific vocabulary. Students should match the keywords on the tagboard strips to the keywords on the chart. Students should tell what the words mean.

(2) Copied, illustrated or labeled by the students and retained by them as a personal record of the experience.

(3) Retained as a class chart and reread by students.

(4) Duplicated by the teacher for inclusion in a class-made science book.

Resources

Jeanne Bendick, *Starting Points in Science* (Lexington, MA: Ginn and Co., 1977) . . . available from Ginn and Co., 191 Spring Street, Lexington, MA 02173

the Framework . . .

PARTICLES IN MOTION–4-6

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	2, 17, 27
II	2, 11, 13
III	
IV	1
V	1, 6
VI	
VII	

Unit or Course Goal(s) Students will be able to gain clear meaning of science words they encounter.

at Work . . .

Time One 20-minute period

Materials Blackboard and chalk or paper and felt-tip pens

Implementation DIRECTED SCIENCE READING ACTIVITY

1. Developing readiness

   a. Have students, as a total class activity, list all they know about particles in motion. Sometimes they will give information that is false. If the reading material will clarify the misinformation, allow the statement to remain on the list; if not, suggest that the information be verified through other sources.

   b. Pronounce and write on board the keywords from the text which are explained in the context.

      e.g., conduction (kən duk′ shən); convection (kən vek′ shən)

   c. Select two or three words which are essential to the main concept which may or may not be a part of the student's vocabulary and are not defined in the text.

      e.g., currents; particles

   d. State these words in a sentence; either compose one or take the sentence that occurred in the text.

      e.g., "The paths, or currents, in which the food coloring moved after heating were formed by those particles of water slipping and sliding about the fastest." (p 208)

   e. Ask students to define the words. Students may respond from their background knowledge or be guided in the use of context or a glossary. Perhaps divide the words into suffixes and roots. This will assist in deriving meaning.

   f. Perhaps occasionally state the definition.

2. Guided silent reading

   Establish a purpose for reading. Ask a question, e.g., How does heat get around? Ask students to predict content from title. What will the author write about? If the author poses a question within the text, have the students stop at that point and answer the question.

e.g., "When we say heat flows, what do we mean?" (p 205)

3. Conclusion

At the conclusion of silent reading, check comprehension by asking questions:

Vocabulary: What is temperature?
Fact: Is matter made up of particles?
Inference: How could you change the pressure of a container of gas without changing the temperature of the gas?

4. Oral rereading

Ask students to locate materials and read orally to substantiate contested questions or those which they could not answer.

5. Follow-up

Ask students if there were words or explanations which were unclear in the reading. Perhaps the word "path" becoming "current"? Deal with misconceptions or false information elicited in first step above.

Resources

Roy A. Gallant, Isaac Asimov, *Ginn Science Program: Intermediate, Level B* (Lexington, MA: Ginn and Co., 1975)

the Framework . . .

CIRCULATION OF OCEAN WATERS–7-9

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 3
II	2, 13
III	
IV	
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to answer key questions.

at Work . . .

Time One 20- to 30-minute period

Materials Reference textbook in *Resources* at the end of this activity. Other reference texts could be used with a modified implementation strategy.

Implementation SQ3R (SURVEY, QUESTION, READ, RECITE, REVIEW)

Guide students through the chapter giving the following directions:

STEP 1–Survey

A. Look at and read the boldface type, usually chapter titles and subheadings, throughout the chapter.

Example: Chapter 4–
Circulation of Ocean Waters
4.1 Major Circulation Patterns
4.2 Local Currents
4.3 Tides and Waves
4.4 Erosional Processes
4.5 Shore Deposits
Main Ideas
Vocabulary
Study Questions
Investigations
Interesting Reading

B. Look at and read the captions for pictures, charts, drawings, maps and diagrams.
Example: Figure 4-5 "Turbibity Currents off Louisiana's Gulf Coast are visible in this aerial view." (p 416)

C. Survey italicized words.
Example: Neap tides (p 418), breaker zone (p 421)

D. Read the introductory and concluding paragraphs of the chapter or read the overview (summary).

E. The authors state their goal for the chapter and pose questions along the margin. Read the goal and question. "Where do surface currents begin?" (p 413)

STEP 2–Question

Use the boldface type from each section to make a question. The first heading in this chapter is "Major Circulation Patterns." A question may be: "What are the major circulation patterns?"

STEP 3–Read

Read the paragraph or section to answer the question.

STEP 4–Recite

After reading the chapter recite orally the answers to the question you have formed about each subtopic. If you cannot answer the question successfully, reread the section.

STEP 5–Review

Later, especially before an examination, go back through the chapter posing the questions and answering them. Reread only those parts you have forgotten.

Resources

Margaret S. Bishop, Phyllis G. Lewis, Berry Sutherland, *Focus on Earth Science* (Columbus, OH: Charles E. Merrill Publishing Co., 1976)

the Framework . . .

CHANGES IN GENES–10-12

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	2, 19, 27
II	2, 9, 11
III	2
IV	1
V	1
VI	
VII	

Unit or Course Goal(s) Students will be able to develop a study guide.

at Work . . .

Time One 30-minute period

Materials Sheet of lined paper
Pen or pencil

Implementation STUDY GUIDE

The study guide is developed as a part of the SQ3R study strategy. Once a study guide has been developed for one chapter, the students will find the chapter structures are usually consistent throughout the text.

1. HOW TO DEVELOP A STUDY GUIDE

   a. Divide a sheet(s) of paper into two columns. Column on left is one-third the width of the paper. Questions derived from transposing topic and section headings into questions are written in left column. Answers to the questions are written in right column.
   b. Mark off bottom one-fourth of paper for recording new vocabulary and definitions.
   c. Place the title of the chapter at top of the paper.
   d. Write first question in left-hand column. Read the selection, think about the answer to the question. Briefly state the answer in the right-hand column.
   e. List any new vocabulary or concept and their meaning on bottom fourth of page.

2. EXAMPLE OF A STUDY GUIDE

Study Guide

Chapter 17–*Origin of New Species*

Ask	Record
A. What causes new genes?	mutation
1. How do new genes arise by mutation?	at cell division the DNA molecule in the cell does not duplicate itself
2. When do genes mutate?	the cause of most mutations in unknown; mutation rate is affected by temperature, chemicals, radiation
B. How do changes in genes affect population?	provide a great amount of genetic variety in organisms
1. How frequently do certain genes occur in a population?	variable . . . prediction of frequency based on assumptions from which conclusions are drawn
New words and concepts	Meaning
Mutation	when the new gene is not an exact copy of the original
Population genetics	studies of genes of an entire population

Resources Claude A. Welch, et al, *Biological Science: Molecules to Man* (Boston, MA: Houghton Mifflin Co., 1968)

math and science instruction

Math and science both stress problem solving. In both, students learn to gather, organize and present data. They learn to recognize and define problems. They learn to choose problem-solving strategies. They learn to estimate, to approximate, to predict. In short, math skills and science skills complement each other.

Problems selected in either math or science may be similar. Some should come from the "student world" and should reflect that world in a manner students will accept as realistic or relevant. Some should be activity-oriented, that is, they should make it necessary for students to do other than paper-and-pencil work. Some may be energy problems; others, environmental ones. Still others may be consumer problems or career problems or, perhaps, home economics or industrial arts problems. Whatever the problems, in science, they provide excellent opportunities for students to develop and apply math and other problem-solving skills.

The cause-and-effect concept in science is often expressed in math as the if-then concept. In either, teachers try to help students understand that knowledge, skills and attitudes evolve through a series of developmental learning stages dependent on previous, present and future actions. Ultimately, both science and math teachers want students doing independent investigations at an abstract level.*

*See *MATH in Oregon Schools* (Salem: Oregon Department of Education, 1977), pp 5-11.

the Framework . . .

SIZING UP YOUR PET–K-3

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	16, 20
II	2, 10, 11, 12
III	1
IV	1
V	1, 4
VI	
VII	3, 7

Unit or Course Goal(s) Students will be able to measure animals.

at Work . . .

Time One 30-minute period

Materials
Measuring string or measuring stick
Small pet animal (e.g., gerbil, hamster, dog, cat)
Animal cage

Implementation

1. Have students bring their pet animal to class.

2. Keep animal in its cage until time to be measured. *Caution*: SPECIAL CARE BY BOTH TEACHER AND ANIMAL OWNER IS NEEDED TO PROTECT STUDENTS AND ANIMAL ALIKE FROM EACH OTHER. *Remember*: ANIMALS CARRY MANY INFECTIONS THAT HUMANS ARE SUSCEPTIBLE TO.

3. With the appropriate measuring device (e.g., measuring string or measuring stick) determine the following dimensions of their animals.

4. Measurements
   - height of animal
   - length of animal
   - tail
   - tummy girth

5. Which animal is tallest? longest? fattest?

6. Measure each animal's cage.
   Is there room enough for the animal to stand up? lie down? stretch out? hide in a corner?

Resources Oregon Department of Education, *Measurement. . .with Metric* (Salem: Oregon Department of Education, 1977)

the Framework . . .

MEASURING SOIL COMPACTION–4-6

State Goal(s) INDIVIDUAL, LEARNER, PRODUCER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	9, 20, 23
II	10, 11, 12
III	1, 2
IV	1
V	3
VI	7
VII	

Unit or Course Goal(s) Students will be able to measure the compaction of soil in a variety of locations.

at Work . . .

Time One 45-minute period

Materials Soil-compaction gauge (use attached plans to build your own)

Implementation With the soil-compaction gauge, have students determine how hard the soil is in the following types of places (or add others):

On a dirt path
Under a tree
On the slope of a hill
At the bottom of a hill
Near a building
In the infield of a ball diamond
In the outfield of a ball diamond
In a garden
In a flower pot

Have them record data, using the following chart format.

PLACE	GAUGE READING

PLACE	GAUGE READING

Will it matter if some of the places are wet?
What conclusions can you reach about soil compaction and plant growth?

Extension

Measuring Water Absorption

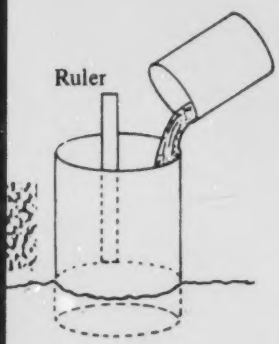
Materials needed:

Large can (a 0.89 kg coffee can or large fruit juice can) with both ends removed
Litre container
Bucket for water
Plastic metric ruler
Watch (indicates seconds)
Two students (per team)

Procedure:

Push the can firmly into the ground so water won't leak out around the edges
Pour exactly one (1) container of water into the can
Record the water level every 10 or 15 seconds in a table. Example below.

Time (Seconds)	Reading on Ruler	Difference
0		



Location _____

Soil compaction number (if you have it)____

Extension:

Plant bean seeds in pots with different soil.

Compactions:

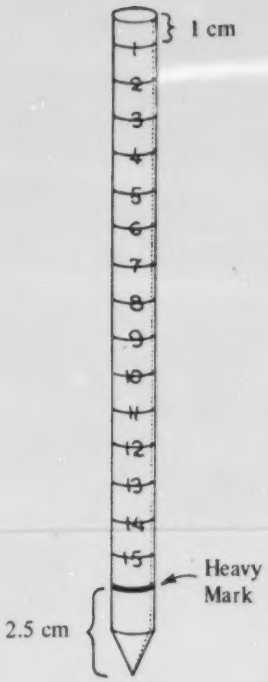
Record their growths. Part of the difference is lack of water absorption, part is difficulty of root growth.

PLANS FOR MAKING A SOIL-COMPACTION GAUGE

Caution: THE GAUGE CAN BE USED AS A BOW AND ARROW. A THIRD THUMBTACK CAN BE PUT ON THE *BLUNT* END TO KEEP IT FROM GOING THROUGH THE SPOOL. HAVE STUDENTS KEEP THE DOWELS *OUT* OF THE SPOOLS EXCEPT WHEN THEY ARE USING THEM.

Materials Needed:

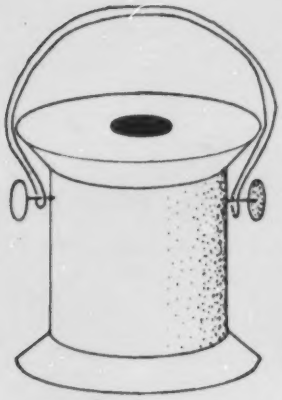
Empty spool
Wide rubber band
Two (2) thumbtacks
Dowel (20-25 cm piece—must fit into spool hole)

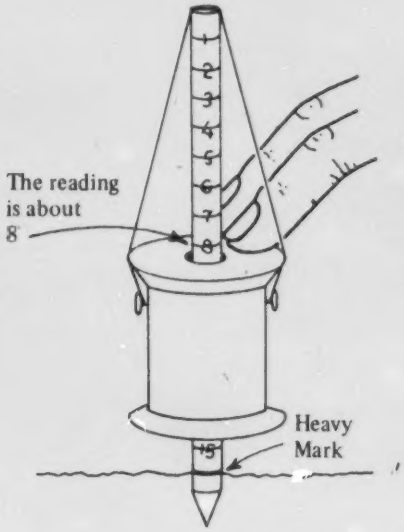


Procedure:

1. Marking the dowel
   - Sharpen one end of the dowel (but not *too* sharp!)
   - Starting at the other end, make a mark on each centimetre mark
   - Number the marks
   - Make a heavy mark 2.5 cm from the tips. (This will show how far the gauge is stuck in the ground.)

2. Fastening rubber band to spool
   - Fasten the rubber band to the spool as in the following sketch. If you have a stick shorter than the size shown above, double the rubber band.





3. Using the Gauge
   - Put the dowel through the spool
   - Put the rubber band on the blunt end
   - Push on the *spool* to force the sharp end into the ground to the heavy mark. (Don't push the stick with your hand. Let the rubber band push the stick.)
   - Read the number on the scale.

Resources

The Mathematics Resource Project, "Mathematics and Environment" in *Mathematics in Science and Society* (Eugene, OR: Department of Mathematics, University of Oregon, 1976) . . . available from Creative Publications, PO Box 10328, Palo Alto, CA 94303

the Framework . . .

AS THE PENDULUM SWINGS–7-9

State Goal(s) **INDIVIDUAL, LEARNER**

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 3, 26
II	10, 12, 15
III	1, 2, 3
IV	1, 3
V	1, 3
VI	
VII	3, 7

Unit or Course Goal(s) Students will understand the mechanics of the pendulum.

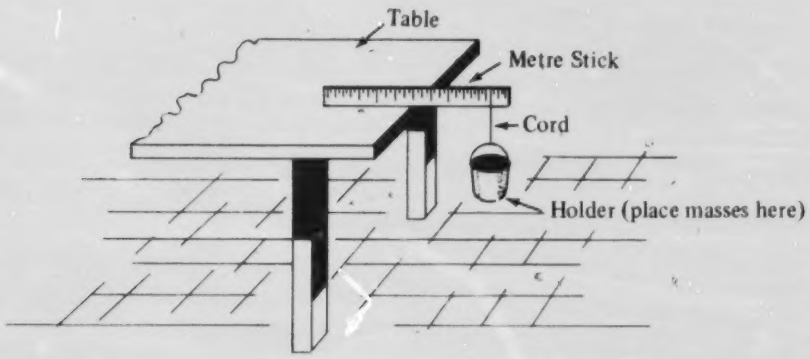
at Work . . .

Time One 50-minute period

Materials Ringstand apparatus for pendulum
metre stick
length of cord
holder (paper cup or small can)
mass pieces (e.g., 50 g, 100 g)

Implementation

1. Rig ringstand apparatus for pendulum experiment.



2. Establish fixed time interval, e.g., one minute.
3. Record number of swings (frequency) of pendulum as length, mass and displacements are varied.
4. Use students to time, count, modify pendulum and record data.
5. Have students suggest ways to modify the pendulum.
6. Coordinate all activities as the class works as a unit to construct tables of data.

7. Discuss tables in terms of variation as time permits. Key questions, "How does *frequency* change (vary) as *length* increases or decreases?"

8. Assignment:
   Construct graphs for length and frequency, mass and frequency, and displacement and frequency. Selected individuals work on acetate sheets for overhead projection.

Resources

Oregon Department of Education, *MATH in Oregon Schools* (Salem: Oregon Department of Education, 1977)

the Framework . . .

IS THE SUN WITHIN RANGE?–10-12

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	20, 23
II	5, 6, 10
III	1, 2
IV	1
V	1
VI	3
VII	3, 4, 7

Unit or Course Goal(s) Students will discover that the distance to the sun is too great to be accurately measured with a range finder.

at Work . . .

Time One 45-minute period

Materials Range Finder (Use plans on p 63 to build your own.)

Implementation Procedure: Build the range finder and try it in the room (see p 63).

Caution: DO NOT LOOK DIRECTLY INTO THE SUN.

Line up shadows cast by the pins of the range finder.

Read the distance to the sun from the scale.

Note that the angle between the sighting bar and the dotted line is too small to measure, the sighting bar appearing to be directly over the dotted line. See figure 8.

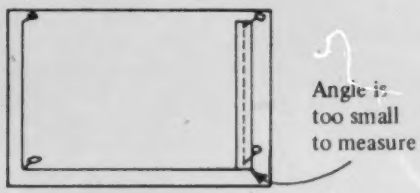


FIGURE 8

Since this range finder cannot accurately measure the distance to the sun, try alternating the device. Investigate the effect of lengthening the baseline (use two boxes side by side). How does this affect the greatest distance you can accurately measure with the range finder?

How long a baseline do you think is needed to measure the distance to the sun?

In sighting an object, the angle formed by the sighting bar and the dotted line is the same size as the angle formed at the object (alternate interior angles formed by two parallel lines and a transversal). See Figure 9. As the distance from objects increases, the angle between the sighting bar and the dotted line becomes smaller.

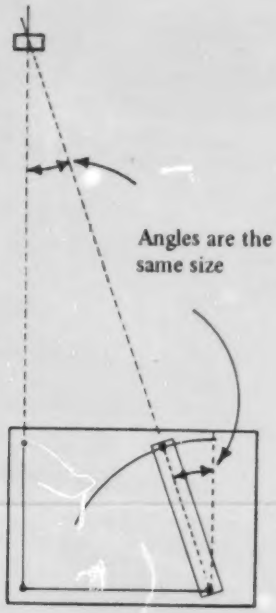


FIGURE 9

PLANS FOR CONSTRUCTING A RANGE FINDER

Materials

Cardboard box (at least 50 cm long)
Clean butcher paper (to cover top of box)
Four straight pins
Strip of heavy cardboard (3 cm x 30 cm)

Procedure

Place a large sturdy cardboard box upside down on the table.
Cover the upper surface with clean paper.
Draw a straight line segment along one of the long sides and label it the baseline.
At one end draw a line segment perpendicular to the baseline and label it the sighting line; at the opposite end draw a dotted line parallel to it.
Place straight pins upright at both end points of the sighting line.
Construct a sighting bar from a piece of heavy cardboard (3 cm x 30 cm). Draw a line segment in the center and place straight pins upright at both end points.

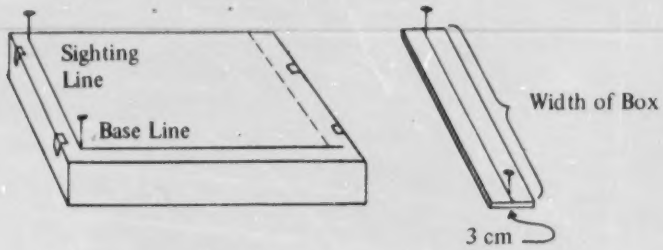


FIGURE 1

Before trying to measure the distance to the sun with the range finder, practice using it.

Pick out an object on the opposite side of the classroom. Position the range finder so that the sighting line lines up with the object. Place the sighting bar at the other end of the baseline so that it lines up with the object. See Figure 2.

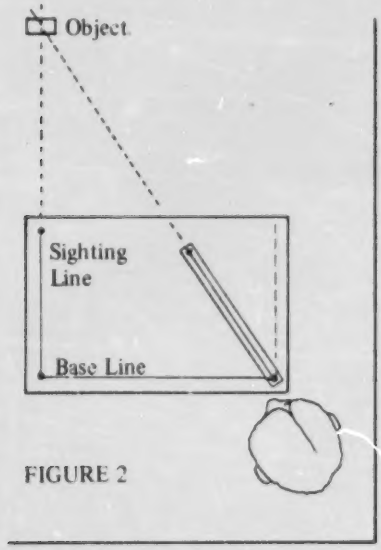


FIGURE 2

FIGURE 3

Move the range finder along the broken sighting line so that it is closer to the object. Since the sighting bar no longer lines up with the object, it must also be moved. See Figure 3.

Place the range finder along the broken sighting line at varying distances from the object and align the sighting bar. You will notice that as the range finder is moved closer to the object, the angle between sighting bar and dotted line increases. Conversely as the distance increases the angle decreases. See Figure 4.

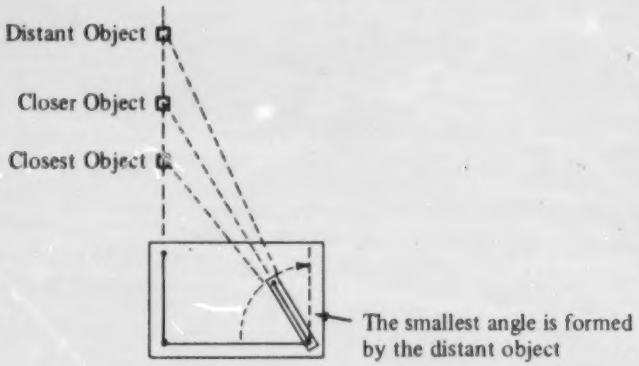


FIGURE 4

The range finder can be calibrated to read distances directly. Draw an arc of a circle on the range finder as shown in Figure 5.

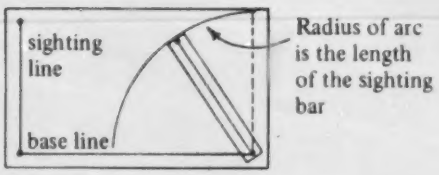


FIGURE 5

Set a sighting range by marking distances of 1, 2, 3, 4, 5, 10 and 15 metres from some object to be sighted.

Place the range finder at each of the distances, align the sighting bar and mark the distance on the arc. (Be sure to place the range finder so that each distance from the object is measured from the rear pin on the sighting line.) See Figures 6 and 7.

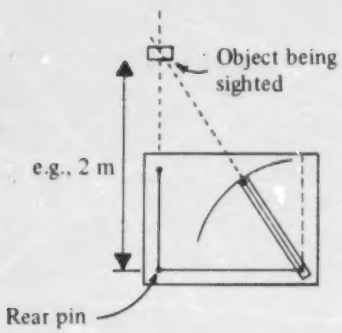
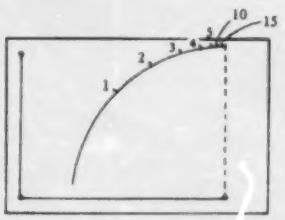


FIGURE 6



A completed scale. The marks and labeling for 5, 10 and 15 metres will be close together.

FIGURE 7

Having built the range finder and tried it, return to page 61.

Resources

The Mathematics Resource Project, "Mathematics and Astronomy" in *Mathematics in Science and Society* (Eugene, OR: Department of Mathematics, University of Oregon, 1977) . . . available from Creative Publications, PO Box 10328, Palo Alto, CA 94303

career education and science instruction

Career education should affect science instruction at all grade levels. Students should learn about vocations and avocations in science. They should learn how science relates to other studies and work. Students should become aware of rewarding leisure-time science pursuits incidental or even unrelated to possible science vocations. Some might, for example, learn to classify Oregon coastal intertidal marine life simply for the love of knowing.

Such inquiry already takes place in schools. But it is unrealistic to expect schools to meet all needs. Schools should look for and use available resources in the home, community, business, industry, labor, government. Technology in some science-related careers advances so rapidly it is impossible for schools to keep current, if only for budgetary reasons. Schools should find ways for students to gain access to advances to help them avoid leaving school with knowledge already obsolete. Schools should help prepare these same students who may want or need to change vocations at any time, or who may want sometime to take up new avocations.

Science teachers themselves should open these lifelong-learning doors, or they may cooperatively work with career education counselors to do so. Either way, students should be helped to understand themselves and the opportunities and alternatives open to them in science vocations and avocations.

the Framework . . .

SPACE TRAVEL–K-3

State Goal(s) INDIVIDUAL, LEARNER, PRODUCER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	4
II	2, 10, 11
III	1, 2, 3
IV	1
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to participate in a group discussion identifying kinds of work completed by others.

at Work . . .

Time One 30-40 minute period

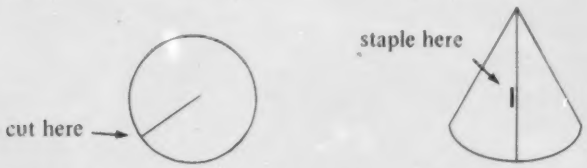
Materials

Balloons
Cardboard toilet tissue roll cores or cardboard mailing tubes (10-12 cm in length)
Soda straws
Ball of string
Manila folder (standard type)
Scissors
Fastening tape (e.g., masking, cellophane)
Poster paints (variety of colors)
Paint brushes (small)

Implementation

1. Secure a cardboard tube to form the body of the rocket.

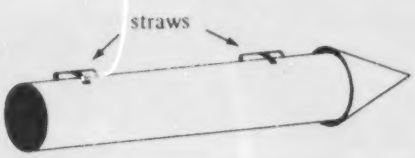
2. Draw a 6 cm diameter circle on a manila folder. Cut out the circular piece. Cut a radius in the piece as shown.



3. Fold and staple the nose cone piece as shown above to form the nose cone.

4. Tape the nose cone to one end of the rocket body.

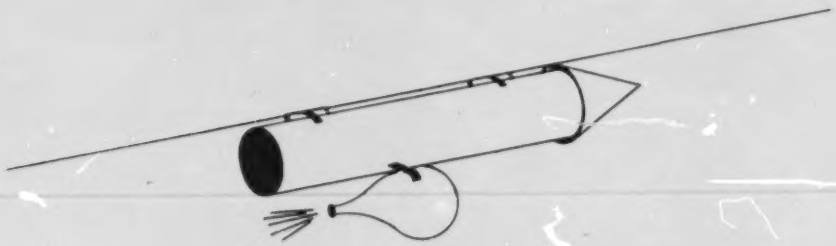
5. Cut two 1.5-2.0 cm lengths from a soda straw. Tape them to the body as shown below to form the rocket guidance system. Paint the rocket (optional).



6. Cut a 2.5-3.0 m piece of string. Tie one end to the back of the chair. Pass the other end of the string through each piece of soda straw that was taped earlier to the body of the rocket.

7. Blow up a balloon with air and tape it to the body of the rocket, as shown (the balloon is the propulsion system). *Do not let the air out of the balloon.*

8. Hold the string tight and let go of the balloon and rocket body. The rocket will be propelled along the string. Record the distance each student's rocket travels.



9. Class Discussion:
   What scientific principles have just been demonstrated?
   What part of the activity could only be done by you alone; what part could have been done with others?
   How does the model and this activity simulate what really occurs in space flights?
   What types of work are usually done alone? What types with others?

Resources

Oregon Department of Education, *Career Awareness Curriculum Kit: Grades K-3* (Salem: Oregon Department of Education, 1978) . . . available from Continuing Education Publications, PO Box 1491, Portland, OR 97207

the Framework . . .

JOB SKILLS AND SCIENCE SUBJECTS–4-6

State Goal(s) INDIVIDUAL, LEARNER, PRODUCER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 11
II	
III	
IV	2, 5
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to participate in a class discussion to explain the relationships between school science subjects and job skills.

at Work . . .

Time Two or three 45-minute periods

Materials Drawing paper or magazines

Implementation

1. Divide class into small groups (three or four students per group) for beginning bulletin board activity.
2. Each group selects one science subject area such as forestry, biology, oceanography, etc.
3. Each group selects and cuts from magazines or draws pictures of job skills that relate to the science subject area it selected.
4. Section off the bulletin board into science subject areas.
5. Each group displays its job skills in the appropriate subject area section of the bulletin board.
6. The class will discuss the relationship of science subject areas and displayed job skills.

Resources Oregon Department of Education, *Career Awareness Curriculum Kit: Grades 4-8* (Salem: Oregon Department of Education, 1978) . . . available from Continuing Education Publications, PO Box 1491, Portland, OR 97207

the Framework . . .

FIELD TRIPS TO SCIENCE-RELATED AREAS: BUSINESS, INDUSTRY AND PROFESSIONAL SERVICES–7-9

State Goal(s) INDIVIDUAL, LEARNER, PRODUCER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	
II	2, 11, 13
III	
IV	2, 5
V	1, 2, 3
VI	3
VII	

Unit or Course Goal(s) Students will be able to list the basic skills and training needed in the science-related occupations observed.

at Work . . .

Time Three to five 45-minute periods

Materials List of questions that can be asked on the field trip(s):

What are the basic skills needed for this particular occupation?
What type of training is needed for this type of work?
What are the chances for promotion or advancement?
What courses should I be taking in school that could help me in this occupation?
What are the working conditions like?
Are there any benefits that go with the job?
Do you like your work?
Is there an opportunity to go into business for myself after having a job like this?
Is there a lot of physical activity related to this job?
What are the advantages and disadvantages of this type of job?
What does your job entail and is there a great deal of responsibility?

Implementation

1. Divide the class into two or three groups (no more than ten to a group).
2. Make arrangements for the field trips. (Contact persons, time, transportation, etc.)
3. Brief the students about the field trips and also have them prepare questions to ask employees on basic skills, training, working conditions, dress and benefits. (See sample list under *Materials* above.)
4. Students will take two or three trips to places of business, industry or professional sources within the community.
5. Students will ask questions regarding basic skills, training, working conditions, dress and benefits (from students' prepared list).
6. Students will listen to employees describing their work, basic skills and training needed for employment.
7. Arrange to have students thank the people involved and send a thank-you letter.
8. Students as a class will list on the chalkboard or overhead projector all basic skills and training requirements for the occupation they observed on the field trip.

9. Optional Activity:

   a. Field trips can be videotaped or cassette recorded and discussed in classroom setting.

   b. Videotapes and cassettes can be prepared for use by other classes or departments.

   c. Interviews can be arranged in the classroom for further discussion of qualifications and opportunities.

Resources

Oregon Department of Education, *Career Awareness Kit: Grades 9-10* (Salem: Oregon Department of Education, 1978) . . . available from Continuing Education Publications, PO Box 1491, Portland, OR 97207

the Framework . . .

NEW TECHNOLOGICAL DEVELOPMENTS–10-12

State Goal(s) INDIVIDUAL, LEARNER, PRODUCER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	
II	
III	2, 5
IV	2, 5
V	1
VI	1, 2
VII	

Unit or Course Goal(s) Students will be able to prepare and present a collage of technological developments from early times to present day in a specific career.

at Work . . .

Time Four 45-minute periods; two out-of-class periods

Materials
Research materials (pictures, paintings, drawings, etc.)
Magazines
Glue
Mounting paper
Scissors

Implementation

1. Form class groups of two to three students each. (In some cases, some students may choose to work alone.)
2. Students choose a specific career area to research.
3. Assign students to study each career area according to technological developments in the area from early times to present day.
4. Students will research at least two days in class to find pictures (or make their own illustrations) of tools used throughout the history of their chosen career areas.
5. Students will use two out-of-class days to contact local businesses in their chosen career areas to obtain information on the latest developments in their fields.
6. Students will complete their research of a career area and gather information, pictures or illustrations of their own. They will prepare a collage that represents their career area from early times to present day.
7. Students will present their collages to the class and discuss the changes that have been made in their chosen career areas and the expectations in the future.

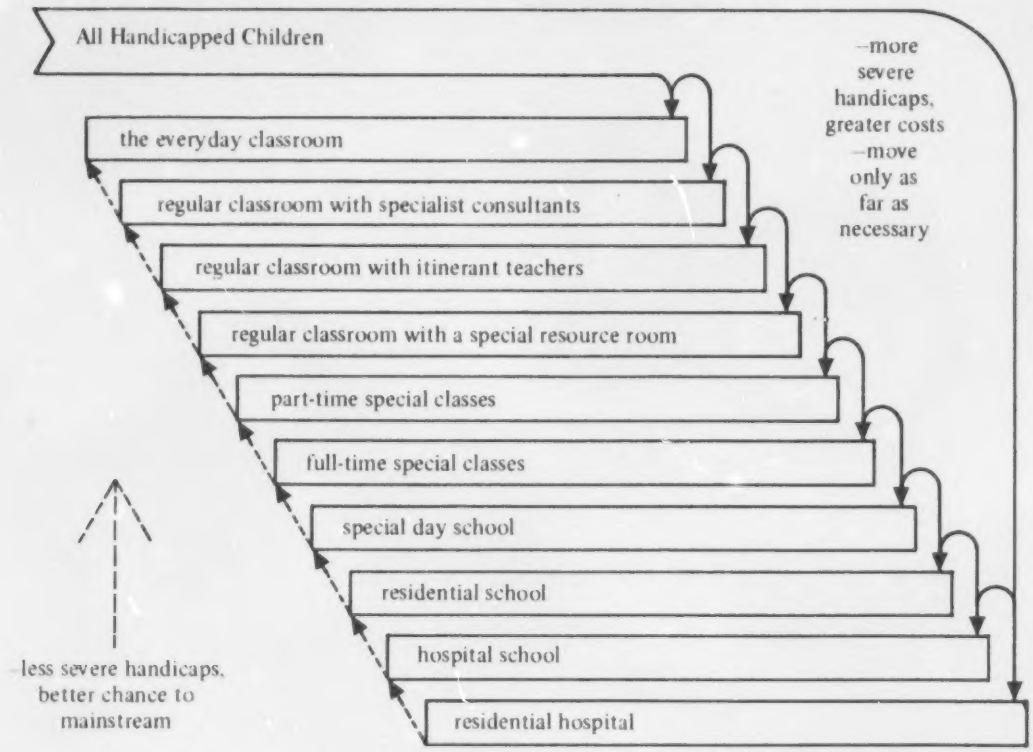
Resources Oregon Department of Education, *Career Awareness Kit: Grades 9-10* (Salem: Oregon Department of Education, 1978) . . . available from Continuing Education Publications, PO Box 1491, Portland, OR 97207

handicapped and science instruction

One in ten children between the ages of five and seventeen has physical or mental impairments to the point she or he needs help not required by other youths. Handicapped children, because of mental, physical, emotional or learning problems, require special education in order to get the education of which they are capable. Public Law 93-380, Part VI B, Education of the Handicapped, calls for schools to educate handicapped children in regular classrooms whenever reasonable. Public Law 94-142 (the Education for All Handicapped Children Act of 1975) further calls for IEPs (individual education programs). For those children identified as handicapped, the IEP assures their access to special services, facilities or materials if their needs cannot be met in regular classrooms.

The Council for Exceptional Children has adopted the "waterfall" model or "cascade" system* to give operational dimensions to the intent of Public Law 93-380. It is a useful tool in designing science programs for the handicapped, for most handicapped children can be taught (mainstreamed) in the regular classrooms with little change in existing programs. With each modification to the normal classroom, fewer students are provided with more services, facilities or materials.

THE CASCADE SYSTEM


All Handicapped Children
the everyday classroom
regular classroom with specialist consultants
regular classroom with itinerant teachers
regular classroom with a special resource room
part-time special classes
full-time special classes
special day school
residential school
hospital school
residential hospital
—more severe handicaps, greater costs —move only as far as necessary
—less severe handicaps, better chance to mainstream

In terms of science education for the handicapped, all this means:

Handicapped persons have been discriminated against in education; the law says now that will no longer occur.

Knowledge of science processes and concepts are as necessary to handicapped persons as to others.

Handicapped persons, given alternatives that deemphasize their handicaps, can succeed in studying science.

*See Maynard C. Reynolds, "A Framework for Considering Some Issues in Special Education" in *Exceptional Children* (March 1962), pp 367-370.

Mainstreaming rests on the premise that handicapped children are more like regular children than they are different from them.

Science curriculum must contain alternatives for breaking communication barriers caused by handicaps.

Resource persons with science backgrounds who also understand the problems related to various handicaps must be available, or a closer relationship between special educators and science educators must be established.

Using hands-on materials for developing and communicating abstract ideas must be continued and expanded.

True inquiry and respect for the ideas of each child must be emphasized.

Differences, especially how long it may take handicapped children to do something, must be respected.

All children learn . . . how well may depend on the skills of the teachers and the strengths of the curriculum.

the Framework . . .

MEASURING LIQUIDS AND DRY SOLIDS–K-3

State Goal(s)

INDIVIDUAL, LEARNER

District Goal(s)

Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	20
II	2, 10, 11
III	
IV	
V	1
VI	
VII	

Unit or Course Goal(s)

Students will be able to share their findings.

at Work . . .

Time

One 30-minute period; additional periods as needed

Materials

Containers with differing volumes (e.g., 0.5 *l*, 1.0 *l*, ml, cl, dl)
Cube (dm^3)
Sandbox, sand
A variety of different sized containers

Implementation

1. Place containers, measuring devices, and supply of sand in an accessible location either inside or outside the classroom.
2. Allow students time to become acquainted with the activity materials.
3. Have students observe and interact with the containers and measuring devices and prepare to share their findings with the class.
4. After approximately 20 minutes, have students share what they have found and record the findings on a chart.
5. Repeat 3 and 4 above each day until each student has used at least three different measuring devices.

Resources

Robert M. Todd, Cherry Houck and Jim Cannon, "Metric Concepts for Children with Specific Learning Disabilities" in *Science and Children* (May 1976)

Educational Development Center, *Elementary Science Study: Sand* (Manchester, MO: Webster Division, McGraw-Hill Book Co., 1970) . . . available from Webster Division, McGraw-Hill Book Co., Manchester Road, Manchester, MO 63011

Educational Development Center, *Elementary Science Study: Drops, Streams, and Containers* (Manchester, MO: Webster Division, McGraw-Hill Book Co., 1971) . . . available from Webster Division, McGraw-Hill Book Co., Manchester Road, Manchester, MO 63011

Science Curriculum Improvement Study, *Subsystems and Variables* (Chicago: Rand McNally and Co., 1970) . . . available from Rand McNally and Co., PO Box 7600, Chicago, IL 60680

the Framework . . .

THERMOMETERS AND HOW THEY WORK–4-6

State Goal(s)

INDIVIDUAL, LEARNER

District Goal(s)

Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	20
II	5, 10, 14
III	2
IV	
V	
VI	
VII	

Unit or Course Goal(s)

Students will know the fundamentals of the thermometer and its application.

at Work . . .

Time

40-minute periods, as many as needed

Materials

Variety of thermometers (e.g., Celsius, nonscaled, Fahrenheit)
Materials for assembling an air-bulb type thermometer (i.e., glass or plastic tubing, jars, bottles or flasks, and cords)
Tap water
Ice
Heat source
Heating containers and miscellaneous containers

Implementation

1. Place thermometers, ice, water and heat source in an accessible area in the classroom.
2. Provide students opportunity to explore using the materials in their own way.
3. Focus on questions or statements:
   a. How do the thermometers differ?
   b. Try to build a thermometer or make your own thermometer scale.
4. After the students have had 15-25 minutes to work with the materials each day, ask them to record and draw pictures of what they found or did.
5. Ask the students to share this information with other students using pictures, demonstrations, etc., for 15 minutes each day.

Resources

Educational Development Center, *Elementary Science Study: Ice Cubes* (Manchester, MO: Webster Division, McGraw-Hill Book Co., 1969) . . . available from Webster Division, McGraw-Hill Book Co., Manchester Road, Manchester, MO 63011

Science Curriculum Improvement Study, *Energy Sources* (Chicago: Rand McNally and Co., 1971) . . . available from Rand McNally and Co., PO Box 7600, Chicago, IL 60680

the Framework . . .

WASP'S NEST–7-9

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	16, 19
II	2, 7, 8, 11
III	
IV	
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to present an idea from gathered data.

at Work . . .

Time One 50-minute period

Materials

- Large nest or home-like structure created by some creature (e.g., paper wasp's nest)
- Paper
- Pencil
- Plastic bag
- Cartons
- Tweezers
- Scissors
- Knife
- Magnifying glasses
- Pieces of white paper
- Microscopes
- Resource books (or library)
- Resource person (if available)

Implementation

1. Place the nest in a place where the students may observe and touch it several days prior to the activity.
2. Display several different kinds of large and small similar structures.
3. Use focusing questions and statements:
   a. What do you think this is or these are?
   b. What do you think made the nest?
   c. Why was the nest built?
4. After each examination (of the nest) session, have the students present their data or evidence and their ideas to the other students.

Resources

Educational Development Center, *Elementary Science Study: Animals in the Classroom*; *Elementary Science Study: Behavior of Mealworms*; *Elementary Science Study: Brine Shrimp* (Manchester, MO: Webster Division, McGraw-Hill Book Co., 1970) . . . available from Webster Division, McGraw-Hill Book Co., Manchester Road, Manchester, MO 63011

Biological Sciences Curriculum Study, *ME NOW* and *ME and MY ENVIRONMENT* (Northbrook, IL: Hubbard Scientific Company, 1972) . . . available from Hubbard Scientific Company, 2855 Shermer Road, Northbrook, IL 60062

the Framework . . .

THE JUPITER EFFECT–10-12

State Goal(s) INDIVIDUAL, LEARNER

District Goal(s) Students will be able to use results of scientific research for the well-being of themselves and others.

Program Goal(s)

I	1, 9, 12
II	8, 12, 13
III	
IV	
V	
VI	
VII	

Unit or Course Goal(s) Students will be able to express their ideas on the movements of bodies in space and their possible effects on man.

at Work . . .

Time Ten 50-minute periods

Materials Book–*The Jupiter Effect* (includes data on dates of major earthquakes and dates of major planet alignments)

Multiple forms of this book (e.g., regular print, braille, tapes and records)

Implementation

1. Provide the students several days to read and/or listen to Gribbon's book.
2. During these days, present some ideas about movement of planets, their periodic alignment and the possible effects this may have on the gravitational fields affecting the earth.
3. Review the gravitational effects of the moon and sun on the earth.
4. Use focusing questions and statements:
   a. Do you believe there will be a major earthquake period during 1982?
   b. What data are you using to support your belief?
5. After three to four days of introductory discussions and questioning, begin an inquiry series of discussions for each student or group to present ideas and supporting evidence for them.
6. Conclude by having students compare their ideas with Gribbon's and Plagemann's ideas.

Resources John Gribbon and Stephen Plagemann, *The Jupiter Effect: The Planets as Triggers of Devastating Earthquakes* (New York: Walker and Co., 1974)

SAFETY IN SCIENCE PROGRAMS

A trend in science education toward more student participation in the *processes* of science brings with it concerns for positive approaches to a safe environment in the laboratory. According to the National Safety Council, about 32,000 school-related accidents occur each school year. About 5,000 of these are science-related. Junior high grades (7-9) experience the highest frequency of accidents, while elementary grades report the lowest frequency. Perhaps, according to another source,[1] one major accident occurs each year for each 40 students in laboratory settings throughout the country.

Safety and health must be integral parts of any science program. Safety must not be taken for granted. For example, in 1970, one researcher[2] found in high school science programs:

advanced placement groups have the most accidents

class enrollment and laboratory space have a significant relationship to laboratory accidents—the higher the enrollment and the smaller the space, the higher the frequency of accidents

fewer accidents occur when individual laboratory stations exist

the chemistry class is more prone than others to laboratory accidents

Dangers come with science programs. Voluntary safety programs are often ineffective. Individuals working in laboratories occasionally take shortcuts, circumvent safety rules and take risks to do their jobs. Carelessness and negative or apathetic attitudes toward safety cause accidents. Yet, with careful planning, most dangers can be safely avoided. Obeying safety rules becomes everyone's responsibility. Enforcing safety rules becomes the teacher's responsibility. And the teachers must have administrative support.

Recognition of safety and health problems has crystallized since passage of the Occupational Safety and Health Act of 1970. Certain precautions must now be observed to protect the safety and health of employees on the job in states that have state occupational safety and health plans accepted by the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor. Absence of similar federal law requiring safety and health programs for the protection of students in schools does not mean districts can relax.[3] Rather, it means they ought to take the lead. They must teach, practice and enforce safety rules.

Even if certain safety and health precautions were not mandated, moral, ethical and social reasons demand that school science laboratories be made as safe as possible for teachers and students alike. Legally, school districts may be held liable for injuries students may suffer in a school laboratory. Districts must establish safety and health instruction as a fundamental part of science curriculum. True, not all accidents and personal injuries occur as results of unsafe practices, but lawsuits instigated over injuries to students in school science laboratories emphasize the need for requiring safe practices from everyone.

Safety and health training should be considered equally important to all other training in school science laboratories.

Teachers play the most important role in assuring a safe and healthful learning environment. Teachers have an obligation to instruct their students in safety and health practices required in science laboratories. Teachers have two primary duties: instruction and supervision. Not only have courts held that teachers who fail to carry out either may be legally liable for injuries, but failure to provide safety and health instruction and supervision are failures to perform primary teaching duties satisfactorily.

Students have an obligation to practice safety and avoid health hazards. They must learn to overcome tendencies to ignore personal danger over which they can exercise control. They must learn that knowledge and preparation are keys to controlling science laboratory hazards. Knowing about a chemical compound today, for example, may not

[1] George J. O'Neill, Television Series Program Number 1: *Safety in the Science Laboratory*, 1975. Sponsored by the N.E. Tennessee Section of the American Chemical Society in cooperation with WSJK, Knoxville.

[2] John Wesley Brennan, "An Investigation of Factors Related to Safety in the High School Science Program," EdD dissertation, University of Denver, 1970 (ED 085 179).

[3] See, for example, ORS 326.051, 336.072, 654.479, 655 and 656. See also OAR 581-22-280 through 288.

be enough for safety tomorrow. The compound may undergo physical or chemical change. More may be learned about its behavior in the meantime. Students, in short, must learn to anticipate danger.

To help teachers prepare themselves for safety in science instruction—and thereby help their students—materials are available through state-sponsored inservice workshops and upon request from the state science education specialist.[4] *A "Walk-Thru Safety Survey of the School Science Laboratory" follows as an example of these materials. Teachers may use it to*

determine whether a safe environment exists

indicate possible areas of concern and danger

serve as a guide for the design of safe facilities

act as a monitoring device for periodic safety checks

act as a permanent record of an ongoing safety program

[4] For example, portions of *Safety in the School Science Laboratory*, an instructor's resource guide prepared by the National Institute for Occupational Safety and Health (NIOSH) in cooperation with the Council of State Science Supervisors (CSSS) and other organizations. Contents include NIOSH regulations; worksheets for hazard analysis and evaluation, for safety program objectives and evaluation, for student projects; an inspection sheet for controlled chemicals; recommendations for labeling; first-aid treatments; a walk-thru safety survey; . . . plus extensive references including films and organizations.

Walk-Thru Safety Survey of the School Science Laboratory

Complete the following pages for your school. If desired, send copies to your principal, superintendent and state science education specialist. Be sure to keep one copy on file for yourself. *Repeat at least annually.*

NAME _____ DATE ____ ____ ___
(mo) (day) (yr)

TITLE _____

SCHOOL _____

DEPARTMENT _____

CITY _____ STATE _____ ZIP _____

1. Number of science teachers in the department _____
2. Number of science teachers with safety training _____
3. Number of science laboratories _____
   a. Recommended student capacity _____
   b. Actual student capacity _____
4. Number of science classrooms _____
5. Number of combined science classroom/laboratories _____
6. Number of exits per laboratory _____
   a. Locate exits by layout diagram (attach)
   b. Exits properly marked Yes _____ No _____
   c. Storage rooms properly marked Yes _____ No _____
7. Number of fire extinguishers

	Type		Location
a.	CO_2	_____	_____
b.	Soda Acid	_____	_____
c.	BC	_____	_____
d.	ABC	_____	_____
e.	Water	_____	_____

8. Number of backup extinguishers in storage _____
9. Last inspection date for fire extinguishers _____
10. Number of sand buckets w/sand _____
11. Number of approved fire blankets _____
12. Number of first aid or emergency charts _____
13. Number of first aid kits w/supplies _____
14. Number of safety showers that work _____
    a. Industrial type _____
    b. Hand or portable type _____

15. Number of eyewash stations _____

    a. Installed w/plumbing and aerifier _____
    b. Squeeze-bottle type _____
    c. Other _____

16. Stations checked regularly to see if they work Yes _____ No _____

17. Eye, face and body protection

    a. Number of approved safety glasses w/full side shields _____
    b. Number of approved safety chemical goggles _____
    c. Number of approved plastic face shields _____
    d. Number of demonstration safety shields _____

18. Each student have his/her own personal eye protection device Yes _____ No _____

    If no, is there a maintenance and cleaning program Yes _____ No _____

19. Number of rubber gloves _____

20. Number of rubber/plastic/cloth aprons _____

21. Number of asbestos gloves (pairs) _____

22. Number of lab coats _____

23. Number of electric outlets (110-120 volt w/ground) _____

24. Number of electric outlets (110-120 volt wo/ground) _____

25. Provision made for proper grounding of all electrical devices Yes _____ No _____

    If no, please describe _____

26. Number of compressed gas cylinders _____

    Properly secured to prevent tipping Yes _____ No _____

27. Number of sinks _____

28. Number of waste receptacles for glass _____

29. Number of waste receptacles for dry chemicals or reagents _____

30. Number of waste receptacles for liquid chemicals or reagents _____

31. Number of containers designed to transport dangerous chemicals or reagents _____

32. All waste receptacles properly marked Yes _____ No _____

33. All waste receptacles easily located Yes _____ No _____

34. Number of securable chemical storage spaces with forced ventilation _____

35. Number of securable chemical storage spaces without forced ventilation _____

36. Number of electric refrigerators _____

37. Briefly describe what type of materials are stored in refrigerators, such as reagents, food, etc. _____

_____

_____

38. Number of fume hoods _____

Rated exhaust velocity – cfm, if known _____

39. Number of exhaust fans _____

Rated exhaust velocity – cfm, if known _____

40. Fume hood rated explosion proof _____

41. Number of drinking fountains in science classrooms _____

42. Number of drinking fountains in science labs _____

43. A master cutoff for water Yes_____ No_____

44. A master cutoff for gas Yes_____ No_____

45. A master cutoff for electricity Yes_____ No_____

46. Cutoffs are accessible Yes_____ No_____

Location of cutoffs is known Yes_____ No_____

47. Floors nonskid Yes_____ No_____

48. Sharp-edged furniture in the lab Yes_____ No_____

49. Number of special cabinets to store hazardous or flammable chemicals _____

50. Number of burners _____

a. Gas _____
b. Alcohol _____
c. Candles, if used _____

51. Animals used in the lab _____

If so, are there proper facilities to handle them Yes_____ No_____

52. Teacher aware of the biohazards involved in animal handling Yes_____ No_____

53. Experiments conducted using biological fluids Yes_____ No_____

What source? _____

_____

54. Blood-letting experimentation takes place Yes _____ No _____

If so, are disposable lancets and alcohol swabs used Yes _____ No _____

55. Students handle pathogens Yes _____ No _____

If yes, explain _____

_____

_____

56. Pipette bulbs used for proper pipetting procedures Yes _____ No _____

57. Is food preparation/consumption/storage permitted in laboratory? Yes _____ No _____

58. Proper facilities to accommodate handicapped students Yes _____ No _____

Explain _____

_____

_____

_____

_____

_____

_____

59. Field manuals or explanatory sessions used to describe possible danger involved with field trips? Yes _____ No _____

60. Teacher is properly trained to conduct safe and healthful science laboratory experimentation Yes _____ No _____

If no, contact your state science education specialist for available training

OTHER COMMENTS

ASSESSING SCIENCE PROGRAMS

In the Goal-Based Planning for Science section of this guide, four sets of desired outcomes were identified: (1) state goals; (2) district goals; (3) program goals; (4) course goals. Competencies were discussed. Personal goals of individual students were mentioned. These were followed by sample science activities and an emphasis on safety in science programs—all designed to assist the planner in implementing a goal-based curriculum.

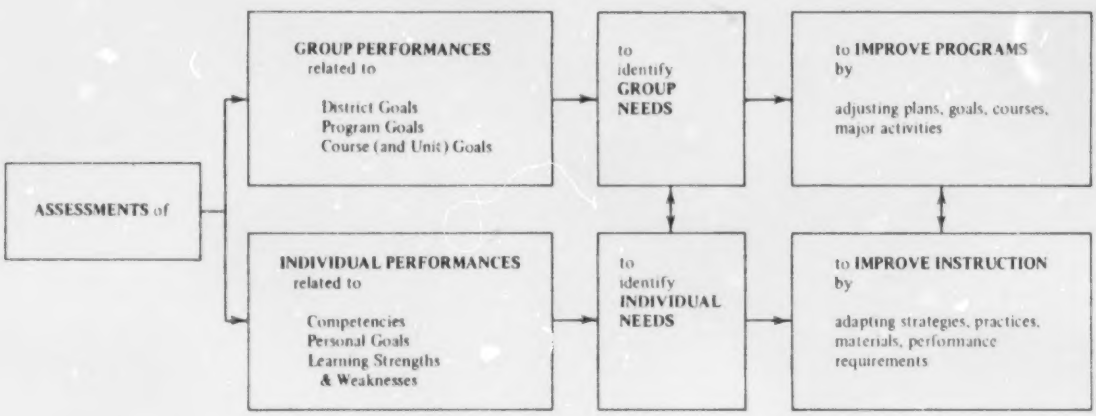
Once instructional plans are implemented, the teacher must pose the question: Are students attaining desired outcomes, and is the science program helping them to reach those outcomes? The quality of the answers to these questions depends on for what purpose and how well assessment activities are designed and carried out.

To measure the attainment of any goal or competency (Was it reached? . . . **not** Why? or Why not? or even How well?), Oregon uses **ASSESSMENT**. Assessment in Oregon means **taking inventory**—asking, Where are we? Evaluation means **judging the inventory(ies)**—asking, What did we intend to do? What did we do? How well did we do it? What would we do differently if we did it over? Assessment and evaluation are **not** synonyms in Oregon.

If it is desirable to know the kind of overall job the science program is doing, then the performance of groups of students is significant. Assessment focuses on whether an acceptable majority of students is attaining established goals. The needs of groups of students can then be identified and program planning improved accordingly. If, however, it is desirable to know how well individual students are attaining desired (or required) outcomes, then the performance of each individual student is significant. Assessment focuses on the needs, interests, and learning strengths and weaknesses of individual students as they strive to develop and demonstrate desired outcomes. The needs of individual students can then be identified and learning activities, teaching strategies, resources, etc., adjusted accordingly.

These relationships are shown below. Assessment of each of the elements shown in the figure will provide answers to particular kinds of questions.

ASSESSMENTS OF GROUP AND INDIVIDUAL PERFORMANCES



Assessment of district goal attainment answers the question: To what extent are students attaining the outcomes of schooling the community and its schools desire?

Assessment of program goal attainment answers the question: To what extent are students attaining the outcomes science teachers and curriculum planners desire?

Assessment of course goal attainment answers the question: To what extent are students attaining the outcomes science teachers desire for, say, Biology I?

Assessment of competency attainment answers the question: To what extent is a student demonstrating desired *applications* of what has been learned in order to graduate?

Assessment of personal goal attainment answers the question: To what extent is a student attaining those outcomes designated as of greatest personal importance, need, or interest?

Assessment of learning strengths and weaknesses answers the question: What characteristic reflected by a student's performance can be seen as enhancing or inhibiting attainment of desired outcomes?

In seeking answers to these questions, student performances that can be accepted as indicators of attainment of desired outcomes must be clear. These performance indicators serve to guide the assessment activity in producing the most needed information.

To be in compliance with state requirements, each district must assure that assessment activities are carried out in relation to three points. Assessment of student demonstration of competencies required for graduation and identification of learning strengths and weaknesses are two of these. In addition, the science program may be selected by your district for a special kind of assessment required by the state. If this happens, it will be necessary to analyze the goals of the program to determine the extent to which students must develop or apply reading, writing, and computing skills in attaining those goals. Assessment will then focus on describing how well the necessary skills are being developed or applied.*

Whatever assessment strategies districts may develop, for science this framework of goals and dimensions stands as one way districts may begin to answer other questions. Does the science program, for example,

generate positive attitudes toward science and an awareness of its usefulness in solving problems of concern to students?

build on activities that progress from concrete to abstract experiences and use learning opportunities from students' own environments?

encourage students to develop problem-solving strategies and to understand scientific concepts, processes and phenomena?

provide opportunities for students to perceive the role of science in society and to develop understandings of the nature of science in today's world?

This framework, moreover, may be a way to begin to answer: Are students in science classes getting any lessons and practice in reading, writing and computing?

*Assessment in goal-based planning is described on pages 17-30 in the *Elementary-Secondary Guide for Oregon Schools: Part II, Suggestions* (Salem: Oregon Department of Education, 1977).

RESOURCES

Organization Journals

Science and Children (The National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009) . . . one of three offical journals of the National Science Teachers Association, published eight times September through May: includes articles, book reviews, teaching ideas and program descriptions prepared primarily for improving elementary school science education

The Science Teacher (The National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009) . . . one of three official journals of the National Science Teachers Association, published monthly September through May; primarily for secondary science teachers

Journal of COLLEGE SCIENCE TEACHING (The National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009) . . . one of three official journals of the National Science Teachers Association, published five times a year in September, November, January, March and May

The Oregon Science Teacher (Oregon Science Teachers Association, 6900 SW Haines Rd, Tigard, OR 97223) . . . the official journal of the Oregon Science Teachers Association, published monthly September through May; teaching ideas, conference reports, curriculum reviews, editorials, announcements, and other news for both elementary and secondary science teachers (available through membership in OSTA; for information, contact Specialist, Science Education, Oregon Department of Education)

The American BIOLOGY TEACHER (National Association of Biology Teachers, 11250 Roger Bacon Drive, Reston, VA 22090) . . . the official journal of the National Association of Biology Teachers, published monthly September through May

Safety

Accident Prevention Manual for Industrial Operations (1974) . . . available from National Safety Council, 425 N Michigan Avenue, Chicago, IL 60611 ($30)

Aldrich Chemical Company Catalog (1978) . . . available from Aldrich Chemical Company, 940 W St Paul Avenue, Milwaukee, WI 53233 (no charge)

CRC Handbook of Laboratory Safety (1971) . . . available from Chemical Rubber Company, 2255 Palm Beach Blvd., West Palm Beach, FL 33409 ($42.95)

Chemical and Biological Safety Guide (1965) . . . available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402 (Stock No. 174000383, $3.85)

Fisher Safety Manual (1977) . . . available from Fisher Scientific Company, 711 Forbes Avenue, Pittsburg, PA 15219 (no charge)

Guide for the Care and Use of Laboratory Animals (1974) . . . available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402 (DHEW Publication No. NIH 74023, 70 cents)

Industrial Safety Data Sheets and Chemical Safety Guides (varied dates) . . . available from National Safety Council, 425 N Michigan Avenue, Chicago, IL 60611 (charges vary according to quantity ordered)

Laboratory Waste Disposal Manual (1978) . . . available from Manufacturing Chemists Association, 1825 Connecticut Avenue NW, Washington, DC 20009 ($5.50)

MCB Chemical Reference Manual (Fall 1977) . . . available from MCB Manufacturing Chemists, 2909 Highland Avenue, Cincinnati, OH 45212 (no charge)

Merck Index (1968) . . . available from Merck, Sharpe, and Dohme Research Laboratories, Division of Merck and Company Incorporated, Rahway, NJ 07065

Registry of Toxic Effects of Chemical Substances (1976) . . . available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402 (HEW Publication No. NIOSH 76-191, $13.00)

Safety in the Academic Chemistry Laboratory (1976) . . . available from American Chemical Society, 1155 16th Street NW, Washington, DC 20036 (no charge for five or fewer copies)

Safety in the Chemical Laboratory (no date) . . . available from American Chemical Society, Division of Chemical Education, 20th and North Hampton Street, Easton, PA 18042 (Cost: Vol I [1967] $6.50, Vol II [1971] $6.00, Vol III [1974] $6.50, plus 15% postage & handling)

Activities

Owen W. Cahoon, *A Teachers' Guide to Cognitive Tasks for Preschool* (Provo, UT: Brigham Young University Press, 1974) . . . available from Brigham Young University Press, Provo, UT 84602; this publication also includes an excellent list of suggested readings related to the mental growth of children

Energy and Man's Environment, Inc., *ENERGY and CONSERVATION EDUCATION* (Portland, OR: Energy and Man's Environment, Inc., 1977) . . . available from Energy and Man's Environment, 0224 SW Hamilton, Suite 301, Portland, OR 97201 –this set of energy and conservation instructional materials is presented in three-ring binders: one binder is used for each grade level grouping, i.e., K-3, 4-6, 7-9 and 10-12; several hundred classroom energy and conservation activities are ready for teacher use, and workshop opportunities for local school districts are available and can be arranged through the EME office staff (Cost: $24 per binder; $86 for set of four binders)

Paul B. Hounshell and Ira R. Trollinger, *games for the classroom* (Washington, DC: National Science Teachers Association, 1977) . . . available from Publications, National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009 (Cost: $4 plus 50 cents for handling. Stock No. 471-14710)

Curriculum

Aukerman, Robert C., *Reading in the Secondary School Classroom* (New York: McGraw-Hill Book Company, 1972)

Berelson, Barnard and Gary Steiner, *Human Behavior* (New York: Harcourt, Brace and Worlds, Inc., 1964)

Bigge, Morris L., *Learning Theories for Teachers*, second edition (New York: Harper & Row Publishers, Inc., 1972)

Bruner, Jerome S., *The Process of Education* (Cambridge, MA: Harvard University Press, 1960)

Educational Policies Commission, *Education and the Spirit of Science* (Washington, DC: National Education Association, 1966)

Evans, Thomas, "Scientific Literacy: Whose Responsibility?" in *The American Biology Teacher* (February 1970)

Francoeur, Pearl and Bilhah Eilam, "Teaching the Mammalian Heart to the Visually Handicapped" in *The Science Teacher* (December 1975)

Funkhouser, G. R., *Report of Workshop on Goals and Methods of Assessing the Public's Understanding of Science* (University Park, PA: The Pennsylvania State University, 1973)

Gagne, Robert M., *The Conditions of Learning*, second edition (New York: Holt, Rinehart and Winston, Inc., 1970)

Haney, Richard, *The Changing Curriculum: Science* (Washington, DC: Association for Supervision and Curriculum Development, National Education Association, 1966)

Havighurst, Robert J., *Developmental Tasks and Education*, third edition (New York: The David McKay Company, Inc., 1972)

Holzberg, Robert, "The Educable Retarded" in *Science and Children* (March 1976)

Hurd, Paul deHart in *Steps Toward Scientific Literacy: A Report of College-Level Conferences on Science for Nonscience Majors*, John Butler, editor (Washington, DC: National Science Teachers Association, 1968)

Klopfer, Leopold, "Science Education in 1991" in *School Review* (Fall 1969)

Lamendola, Angelo, "Science and the Emotionally Disadvantaged Child" in *Science and Children* (March 1976)

Lessinger, Leon M., "Accountability for Results: A Basic Challenge for America's Schools" in R. Tyler and L. Lessinger, editors, *Accountability in Education* (Worthington, OH: Charles A. Jones Publishing Company, 1971)

Livermore, Arthur, "The Process Approach of the AAAS Commission on Science Education," in *Journal of Research* in Science Teaching (1964)

Marksheffel, Ned D., *Better Reading in the Secondary School: Principles and Procedures for Teachers* (New York: The Ronald Press Company, 1966)

Mastie, Marjorie and George Johnson, editors, "Science Objectives for 1972-73, Assessment of Educational Progress" (1972) . . . available from Education Commission of the States, Suite 700, 1860 Lincoln Street, Denver, CO 80203 (Order No. ED 072 976, $1)

Molloy, Larry, "Law and the Handicapped" in *Science and Children* (March 1976)

Monaco, Theresa M., "Mainstreaming, Who?" in *Science and Children* (March 1976)

Myklebust, Helmer R., "Learning Disabilities" in *Science and Children* (March 1976)

National Assessment of Educational Progress, "Changes in Science Performance 1969-1973: Exercise Volume Appendix" (1977) . . . available from National Assessment of Educational Progress, Suite 700, 1860 Lincoln Street, Denver, CO 80203 (Order NAEP Report No. 04-S-20, S/N 017-080-01682-6, $13 set [released exercises and results from the first and second science assessments])

Norris, Eleanor, editor, "National Assessment of Educational Progress-Science Objectives" from Committee on Assessing the Progress of Education (1969) . . . available from Education Commission of the States, 1860 Lincoln Street, Suite 700, Denver, CO 80203 (Order No. Ed 033 872, $1)

NSTA Committee on Curriculum Studies, "School Science Education for the 70's" in *The Science Teacher* (November 1971) . . . available from the National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009

NSTA Curriculum Committee, *Theory Into Action in Science Curriculum Development* (Washington, DC: National Science Teachers Association, 1964)

Ogden, William, "A Chronological History of Selected Objectives for Teaching of Secondary School Chemistry in the United States during the 1918-1972 Period as Reflected in Periodical Literature" in *Paper Presented to National Association for Research in Science Teaching Conference Participants* (April 1974) . . . available from National Association for Research in Science Teaching, National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009

Pella, Milton, George O'Hearn and Calvin Gale, "Reference to Scientific Literacy" in *Journal of Research in Science Teaching* (Volume 4, 1966)

Perkins, Hugh V., *Human Development and Learning*, second edition (Belmont, CA: Wadsworth Publishing Company, Inc., 1974)

Showalter, Victor, "A Model for the Structure of Science" in *ERC Papers in Science Education Number 10* (1969) . . . available from Educational Research Council of America, Rockefeller Building, Cleveland, OH 44113

Skinner, B. F., *The Technology of Teaching* (New York: Appleton-Century-Crofts, 1968)

Tyler, Ralph W., *Basic Principles of Curriculum and Instruction* (Chicago: The University of Chicago Press, 1949)

Supervision Planning

Harbeck, Mary Blatt, *2nd Sourcebook for Science Supervisors* (Washington, DC: National Science Teachers Association, 1976) . . . available from the National Science Supervisors Association, a division affiliate of the National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009 (Cost: $3.50 plus 50 cents handling; Stock No. 471-14706)

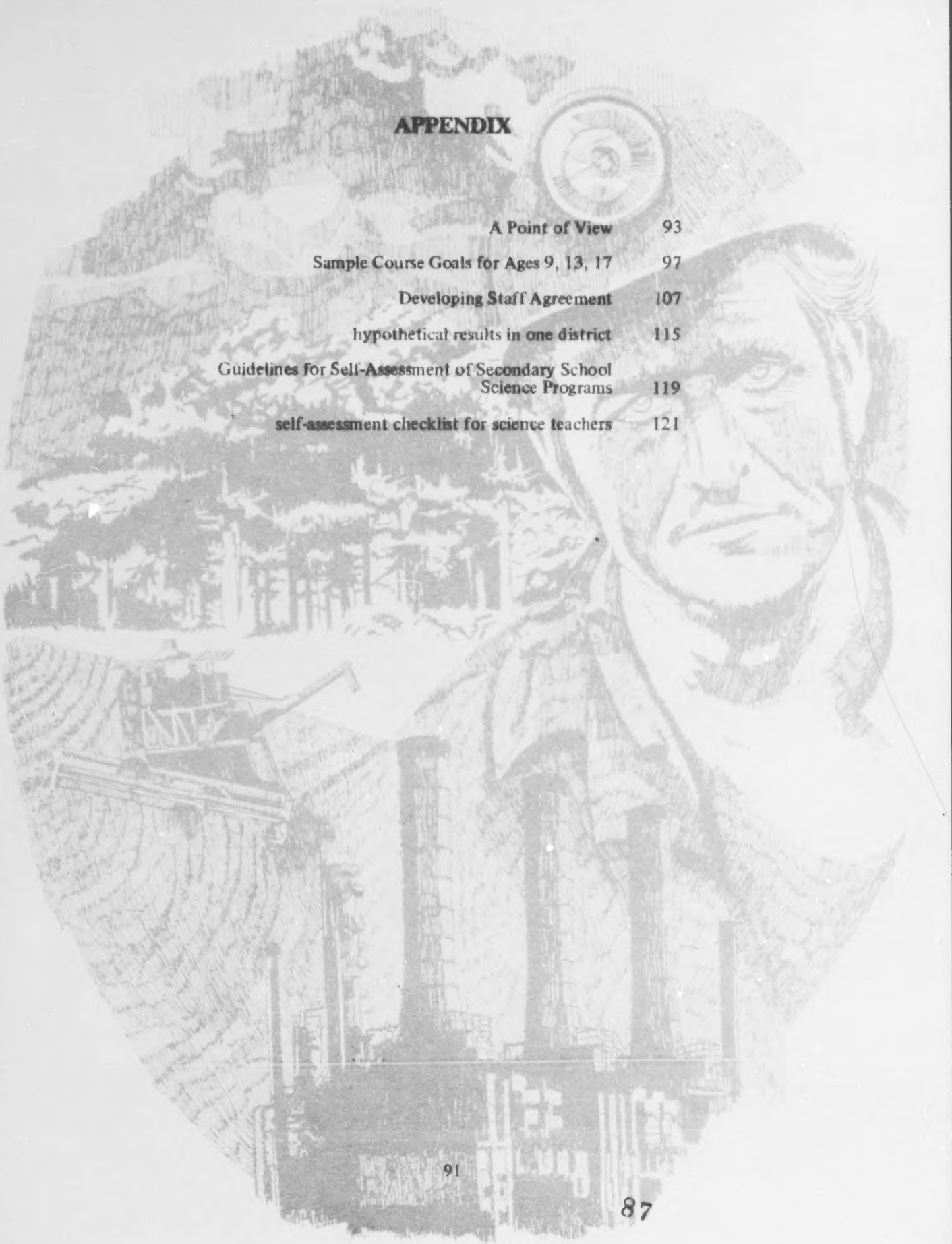
Oregon Department of Education, *Planning the Education of Oregon Learners: Completing the Management Cycle* (Salem: Oregon Department of Education, 1975) . . . discusses the function of statewide assessments and its relationship to identifying needs; traces how identified priorities affect state program operation and how results are evaluated and reported

Oregon Department of Education, *Planning the Education of Oregon Learners: Setting Goals* (Salem: Oregon Department of Education, 1975) . . . presents the statewide goals for education adopted by the State Board of Education in January 1974, and discusses the rationale for setting these "life roles" goals, the methods of involving representatives of Oregon communities in the setting of these goals, and the relationship of the statewide goals to the goals of local school districts

Assessment Evaluation

Buros, Oscar Krisen, *SCIENCE Tests and Reviews* (Highland Park, NJ: The Gryphon Press, 1975) . . . available from the Gryphon Press, 220 Montgomery Street, Highland Park, NJ 08904 for $22

Wall, Janet and Lee Summerlin, *STANDARDIZED SCIENCE TESTS: a descriptive listing* (Washington, DC: National Science Teachers Association, 1973) . . . available from Publications, National Science Teachers Association, 1742 Connecticut Avenue NW, Washington, DC 20009 for $2 plus 50 cents handling (Stock No. 471-14642)



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A Point of View

The Science Guide Steering Committee recognizes that legal requirements for public education establish only the basic framework within which local districts operate as they plan total programs. To move from law and tradition, and to build on dynamic and emerging concepts of science and principles of education, teachers and curriculum writers may want to examine these ideas:

Challenges of Teaching Science
Nature of Science and Its Relation to Society
Learners and Learning Theory
Teachers
Bases for Science Curriculum Development

Challenges of Teaching Science

The predominant challenge to modern science teachers is to help students as youths, citizens and decision-makers to understand the enormous consequences of applied technology. Benefits are clear. But they are countered by problems which threaten whole ways of life, perhaps the existence of life itself. Impending disasters are well known: exhaustion of energy resources, degradation of the environment, population control, resource waste, thermonuclear weapons proliferation and potential nuclear holocaust, famine, ... Presently, the focus of science teaching is the description of the natural world, with some attention given to the ways by which scientists develop that description. In the past this emphasis has been appropriate, possibly adequate. But it is no longer. Science teachers must go farther. The new challenge—the new imperative—for science teachers is to *take action in the classroom on society's science-related problems.*

An additional challenge is found in the recognized ethical and philosophical impacts of science, with this questioning totally separate from the technological consequences. For millenniums, man and woman were the highest creations on earth, and earth, in turn, was the center of the universe. After 300 years of "modern" science, their special position has been questioned, first by scholars and later by more highly educated masses. As science through popular education reveals to more and more people the nature and extent of the universe, even the masses are compelled to question their place in the grand scheme of things. Perhaps, as Schweitzer has said, there is no longer a dividing line between higher and lower, between more valuable and less valuable life.

Not only do such philosophical challenges face science teachers but also such ethical decisions as genetic engineering in the control of both human and nonhuman life, artificial prolonging of human life or arbitrary termination of it under extreme conditions of pain, suffering or imminent death. Scientists and technical specialists are not the only ones who must make decisions in matters of these kinds. Rather, an educated public must participate, and a key place for such education is in the schools.

A genie in the form of science knowledge, its applications, and the emerging ethical and philosophical questions, has been released from the bottle. No one is sure of its powers for good and evil. These developments, reflected in a growing general lack of confidence in science and fear of its consequences, have created new challenges for teachers in science classrooms. Challenges . . . and excitement, for science teachers and students today can try to comprehend the nature of this universe; find unique and powerful ways by which science has opened this world; learn the good and the bad in technological applications of science; search to understand people's place in this universe, their relation to all of nature and their responsibility to it.

Nature of Science and Its Relation to Society

Science teachers are so often immersed in the content of science and its related technologies that they have little time to consider its nature. Frequently their own formal science education has not adequately given them general outlines of the field. Effective teachers should be comfortable with the history of their subject, its conceptual structure, its methodologies, and its technological and philosophical consequences.

Science, a human activity, examines natural phenomena. Rather well-defined criteria delimit the questions asked of nature and declare the data acceptable. Except for scientists who work on the frontier of knowledge itself attempting to formulate new views, most scientists seem to phrase their questions within generally established theoretical frameworks or conceptual models. Rather than operating on unyielding dogma or authority, scientists recognize they move from where others have been before. They work with procedures others can duplicate, expose

their data to responsible critics, and argue their cases and draw their conclusions using logic appropriate to the empirical approach.

Scientists' data-gathering procedures involve instruments, instrumental procedures and other appropriate skills. While these instruments and procedures may frequently appear extremely sophisticated, they are open to the scrutiny of all and are comprehensible to those willing to make the intellectual effort. These aspects of science are basic to its empirical nature and, again, make it essentially public.

From carefully delimited theories and questions and through rigorously controlled but open procedures come facts and conclusions which eventually build to generalizations, laws and conceptual schemes. The original supporting theories, always tentatively held, may be confirmed for the time, or they may be reformulated in the light of new evidence.

Thus the storehouse of scientific knowledge grows and men's and women's conceptions of their universe are enlarged with full expectations that more may be learned and that basic views held today may well be discarded or modified tomorrow.

Such change influences technological applications—in communications, medicines, energy-converting devices, space exploration, weaponry and miracle products of countless kinds. Students, teachers, and public alike commonly understand this part of science. It is easy to think of scientific technology which permeates every part of modern life.

But, as mentioned earlier, teachers and students must begin to study the practical science-related problems nations face. Findings of science have raised new questions. Old questions gnaw.

Effective teachers help students go beyond the content and procedures of science to the science-related problems and concepts we now must understand. Moral and ethical questions are inevitable.

Learners and Learning Theory

Teachers and other curriculum writers must understand the nature of learners and the conditions and forces which motivate learning. Individuals have inherent worth and dignity. They have rights to develop their potential for full lives. These values are clearly set forth in national and state constitutions and related laws and regulations. Landmark court decisions in the past quarter century attest to these values. Every student has a right to the education to assure development of that worth and dignity.

Individuals as learners are unique and dynamic. Individuals come to the classroom from particular social or cultural settings bringing unique bodies, special sets of intellectual capabilities, backgrounds of wholly individual personal experiences, and singular sets of feelings, emotions, values, and goals which make up their totally individual personalities.

These differences suggest the need for variety in curriculum design, a great range of resources and teaching techniques—including opportunities for both individual and group work, and a schedule of activities encouraging the maximum development of each individual's potential. Conditions of physical arrangement, resource availability, emotional climate, student physical or intellectual limitations or endowments should not be allowed to limit opportunities for an individual's education.

Scholars of human growth and development suggest that motivation to behavior—and thus learning—has its source in meeting social, psychological and physiological needs. Humans learn as they live, and as they learn they grow. As humans grow they pass at uneven rates through stages such as infancy, childhood, adolescence and early adulthood. Needs, interests, abilities and goals also change unevenly. Some students need to satisfy curiosity, others to develop physical skills. Still others need to know about and relate in acceptable ways to the many aspects of the environment. Many need to satisfy relations with peers of both sexes, with members of their families, and with persons in the community or around the world. In addition, adolescents and young adults need to establish a sense of personal independence and self-reliance.

Among current theories of learning, two are commonly discussed: stimulus-response theories and cognitive field theories. Operant conditioning[1] is probably the most widely discussed of the stimulus-response theories. In the classroom, student reaction to a stimulus (teacher question, laboratory behavior, test question, fellow-student

[1]See B. F. Skinner, pp 465-480 in Hugh V. Perkins, *Human Development and Learning*, second edition (Belmont, CA: Wadsworth Publishing Company, Inc., 1974).

behavior) followed immediately by a positive reinforcement, if merited, will increase the probability of the same or similar response in the future. Skinner's operant conditioning theory is, of course, quite elaborate, but it finds support and application in the form of programmed instruction, learning situations where small sequential steps to learning can take place, and where certain kinds of undesirable behavior are to be overcome.

Cognitive field theories of learning emphasize perceptions, goals and personal meaning within immediate and total (whole) situations. Cognitive learning involves the use of facts, concepts and principles in thinking processes and problem solving. "Discovery" learning[2] emphasizes learners using their total experiences to grasp underlying principles which give meaning and structure to the subject. Cognitive development is more likely to be achieved through learners' internalizing information selected, organized and presented through a variety of experiences.[3] In cognitive learning it is important for the learner to develop general, inclusive, overarching concepts under which unfamiliar concepts can be grouped and related.

Possibly the most widely quoted theory in education today, one having particular impact on science education at the elementary level, suggests cognitive development takes place in stages during growth from childhood to adolescence:

sensorimotor intelligence (birth to two years)–no conceptual thought but some cognitive development observable

preoperational thought (two to seven years)–language and rapid conceptual development

concrete operations (seven to eleven years)–ability to apply logic to *concrete* problems

formal operations (11 to 15 years)–cognitive structures reach high level of development, and individual can apply logic to classes of problems[4]

These stages should be seen primarily as states of *readiness* for further development. Development in each stage is essential to success in subsequent stages.

Teachers

Excitement in teaching science at any level springs from several sources. Teachers usually find stimulation in their own discovery of the wonders, beauty and order in this universe and find rewards in passing along to their students the same deep feelings and enriching understandings. Teachers like to help students develop first-hand skills in the systematic and rigorous ways scientists go to the field, their laboratories and their libraries to ferret out the secrets of nature. To help students feel exhilaration in making their own discoveries of the natural world in a similar manner is a high point in the experience of science teachers.

For personal self-renewal and to display to students enthusiasm for the subject they teach, science teachers must develop habits of continued study and investigation. Such study may focus on literature in science or in professional education. Participation in scientific activities may come through hobbies, summer employment or study, or travel. Whatever renewal chosen, teachers can maintain vitality in their teaching through programs of continuous learning. Effective teachers stay abreast of developments in their profession, and their rewards are found in both personal satisfaction and in student response to enriched teaching.

Science teachers may somewhat naturally give their personal study time to their special interests. They should keep doors open, however, to study of curriculum development, classroom methodology, and recent developments in materials and resources. Opportunities to pursue these interests can be found in such activities as teachers meetings, regional and national conventions, local or regional committee work, and professional reading. Teachers who recognize the general characteristics of learners, who understand the nature of forces which motivate learning, and who are able to combine these understandings with comprehensive knowledge of the science they teach, are more nearly able to create the positive conditions, atmosphere, and incentives for effective learning.

[2]See Jerome S. Bruner, pp 484-486 in Hugh V. Perkins, *Human Development and Learning*, second edition (Belmont, CA: Wadsworth Publishing Company, Inc., 1974).
[3]See David P. Ausubel, pp 486-487 in Hugh V. Perkins, *Human Development and Learning*, second edition (Belmont, CA: Wadsworth Publishing Company, Inc., 1974).
[4]See Jean Piaget, pp 509-511 in Hugh V. Perkins, *Human Development and Learning*, second edition (Belmont, CA: Wadsworth Publishing Company, Inc., 1974).

Bases for Science Curriculum Development

Common among bases for developing science courses and programs are the subject itself, youth or adolescent needs, and societal problems. Of the three, the second and third seldom receive the attention they may deserve.

The *subject* itself is the most common basis for course or program development. Science as a framework is both practical and functional. Science itself is logical and orderly. Teachers have concentrated their formal education in science. Texts as fundamental sources of classroom literature are science oriented, and texts also become convenient bases for organizing thinking and action.

Youth or adolescent needs can be another basis for curriculum. Such an approach might require science teachers to identify what students need to grow to maturity and then to select appropriate subject matter and experiences for their education. Successfully achieving developmental tasks would lead students to happiness and to success in subsequent tasks.[5] But curriculum materials are not usually prepared with this view sufficiently in mind. Teachers have not been educated to recognize the importance of the concept. They have not lived through an educational system, including their teacher-preparation programs, which values helping young people grow in such functional ways. Perhaps only independently innovative teachers will stimulate action to recognize the needs and developmental tasks concept, but their contribution may be significant.

Societal problems become still another way to develop curriculum. Energy exhaustion, for example, or environmental degradation, overpopulation, nuclear weapons proliferation, drug misuse, genetic engineering, crises in values supposedly have solutions. What are they? The urgency of these problems may be so great that perhaps science can no longer be taught with a take-it-for-granted attitude. Teachers may have to overcome, again, their not having been prepared to teach from the societal-problems point of view. With partial attention given to the problems in at least some classroom literature, and with the obvious relation of the problems to the field of science, teachers may find it reasonable to help students try to solve societal problems.

The best science teaching may be based on all three views, . . . or more. Tradition and logical organization encourage the practice of subject matter emphasis. But an education in science essentially limited to an understanding of the nature of the natural world is inadequate. Education is a social endeavor meant to enrich lives. Thus science teaching must address itself to the lives of students, and the issues and problems facing societies.

[5]Robert J. Havighurst, *Developmental Tasks and Education*, third edition (New York: The David McKay Company, Inc., 1972) pp 2, 4.

Sample Course Goals for Ages 9, 13, 17

Sample course goals here (all with an understood "Students will be able to . . ." or "Students will know . . .") may be used to help develop, assess and evaluate local science programs. Samples are neither intended to be exhaustive nor assumed to be the best. Local districts may select what may be consistent with their own district and program goals. Or, districts may merely use these goals as springboards toward better ones.

Age 9

Match definitions with appropriate terms from a list (e.g., property, organism, change, energy, inference, observation, prediction).

Identify through use of pictures or other suitable illustrations simple classroom equipment associated with science: thermometer, metre stick (or ruler), equal arm balance, magnifying glass, magnets.

Associate function with recognition of the simple equipment names above.

Select an appropriate item of equipment to do a specific job (e.g., a thermometer to gauge temperature).

Predict what will happen to a particular instrument when various interactions occur (e.g., ice added to water–thermometer).

Select or identify simple machines and indicate the work they can do.

Match an observable natural phenomenon with its source (e.g., rain-cloud, community-organism, heat-friction).

Relate growth or change to a natural phenomenon (clouds: evaporation and water, animals: population and reproduction, seasons: rotation and revolution of earth).

Identify where evidence of a once living thing can be found and describe why it is found there, as well as how a living thing moves in its environment and why it moves that way.

Select and identify appropriate characteristics of living things (e.g., rabbit. has fur, bears live young, is a plant eater, has a skeleton).

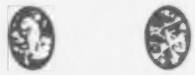
Identify and predict the effect of placing various objects in a fluid.

Apply components of simple laws and principles to predict or alter a situation (e.g., changing a stream system to change the direction of flow or designing an irrigation system; changing a system to make a balanced aquarium or designing a habitat; changing a system to make a boat float or designing a floatable boat).

Identify stable structures from examples.

Identify variables that allow, e.g., a "sinking" object to float, an organism to survive, conservation of energy.

Predict that strong forces produce greater change than weak ones in, e.g., tides, habitat, motion.



Predict the effects of changes in fulcrum, resistance and effort on balance beams.

- Identify a particular reference frame when given a situation.
- Explain how units of matter interact by identifying the interaction that occurs in a given phenomenon.
- Order and group objects through the use of one or more of their senses.
- Quantify measurable items (length, width, mass, etc.).
- Discriminate between an observation and an inference (e.g., a picture of a phenomenon followed by three observable alternatives and one inferable alternative).
- Discriminate between drawings of objects showing basic similarities but one difference.
- Use alternate classification schemes.
- Distinguish mutually exclusive categories from nonmutually exclusive categories.
- Distinguish among appropriate symbols used in various science curricula and elementary science textbooks.
- Make simple interpolations and extrapolations from data tables and graphs.
- Replace the missing object from alternatives found in a set of sequentially sized objects (or pictures of objects) that has one object missing.
- Choose correct inferences from among several choices found in a short paragraph describing an event.
- Identify simple variables in relationships or interactions in all science fields.
- Take additional science courses. (Assessment items should assess student variables through multiple response techniques.)
- Express an attitude toward previous science courses. (Assessment items may emphasize, for example, classroom environment, teacher attitude, enjoyment of previous science classes.)
- Pursue science-oriented hobbies (collections, record keeping, clubs, TV programs, books, rockhounding, museums, games) as a direct result of taking a science class.
- Indicate the extent to which they see beauty in nature and do any science-related things in the outdoors for just sheer enjoyment.
- Explain the necessity and purpose of such outside-school agencies as Department of Land Conservation and Development, Department of Environmental Quality, Department of Geology, Astronomical Society, Corps of Engineers, etc.
- Name several pros and cons for such issues as strip mining, forest clear-cutting, building large dams.
- Indicate the extent to which they use any process or content skills in other academic areas or extracurricular activities.

Conserve natural resources as a result of their experiences in formal science.

Explain a scientific perspective concerning commerically manufactured products.

Explain a perception of the uses of natural resources and manufactured products.

Age 13

Apply appropriate terminology to describe familiar scientific phenomena (e.g., planet, eclipse, fossil, bacteria, predator, photosynthesis, gravity, circuit, lever).

Identify by name simple scientific equipment (e.g., barometer, telescope, microscope, graduated cylinder, balance, tuning fork).

Identify the appropriate item of simple scientific equipment required to complete a selected task (e.g., using a microprojector to magnify and project an image of a pinch of sand, using a microscope to identify organisms in a sample of pond water, using a balance to measure mass of a rock).

Explain simple cycles (e.g., carbon cycle, reproductive cycle, matter cycle).

Explain why the force of change is active on both living and nonliving things.

Explain why bodies in space are in continuous change.

Explain why the earth is undergoing a continuous process of change.

Explain why the sun is the earth's chief source of energy.

Match or associate structure with function in a living system.

Explain basic predator-prey relationships.

Explain how heredity and environment influence.

Identify schemes involved in ecology.

Explain the particulate nature of matter.

Predict the effects which various forces have upon objects.

Explain that one's environment is regulated by a number of laws and principles. (Concern at this level should be with a qualitative knowledge of the simple laws of motion, genetic laws, conservation of mass and energy.)

Relate the appropriate description of a law or principle to a given phenomenon (e.g., tides and gravitation, natural selection and genetic continuity, conservation of matter and energy).

- Apply classification systems.
- Identify cause-and-effect relationships.
- Identify constant forces of change throughout the universe.
- Categorize things based upon relevant properties (e.g., color, shape, size).
- Identify and describe properties of matter.
- Select alternate ways of classifying a given set of objects.
- Distinguish between appropriate and inappropriate criteria for classification.
- Use appropriate categories (taxonomic keys) to organize knowledge.
- Use the metric system for measurement.
- Use decimals and fractions in scientific measurement.
- Identify formulas for such common compounds as carbon dioxide, simple sugars, alcohols, DNA-RNA.
- Interpret simple equations for rusting, respiration, work.
- Express regularities in mathematical symbols using scientific notation and proper significant figures.
- Match properly a list of 15 symbols and definitions (e.g., λ = wavelength, P = momentum, V = frequency).
- Interpolate and extrapolate conclusions from appropriate data.
- Predict the consequences of removing or altering one or more elements in a system.
- Infer possible causes and outcomes from a selected scientific phenomenon.
- Construct more than one inference from a given set of data.
- Demonstrate that models used to explain phenomena are not understood completely or observed directly (e.g., solar systems, genes, atoms).
- Identify adequate plans for setting up apparatus and for collecting relevant data.

Identify variables that influence a system and name the suitable controls.

Select the statement that fits the definition of a hypothesis.

Distinguish between a hypothesis and a fact.

Collect and record simple data from observations and measurements.

Extract the important ideas from reading, listening to or watching presentations containing scientific information.

Explain why committing ideas to media presentation does not establish their truth.

Determine the gross limitations in results of experiments reported in the media.

Read numerical values from simple charts, graphs and tables, and apply results to answering simple questions.

Provide logical predictions and conclusions from data and information.

Use information placed in a table, chart, graph, etc.

Formulate appropriate "what" questions relative to a scientific problem that arises from a familiar situation.

Suggest appropriate experiments to solve simple problems.

Take additional science courses. (Assessment items should assess student variables through multiple response techniques.)

Express an attitude toward previous science courses. (Assessment items may emphasize, for example, classroom environment, teacher attitude, enjoyment of previous science classes.)

Pursue science-oriented hobbies (collections, record keeping, clubs, TV programs, books, rockhounding, museums, games) as a direct result of taking a science class.

Indicate the extent to which they see beauty in nature and do science-related things in the outdoors for just sheer enjoyment.

Explain the necessity and purpose of outside-school agencies (e.g., Department of Land Conservation and Development, Department of Environmental Quality, Department of Geology, U.S. Corps of Engineers).

Name several pros and cons for issues (e.g., strip mining, building large dams, forest clear-cutting).

Indicate the extent to which they use any process or content skills in other academic areas or extracurricular activities.

Distinguish facts from falsehood when dealing with advertisements.

Distinguish between nonscience (e.g., astrology, occult) and the unknown or unanswerable at this time (e.g., UFO, ESP).

Indicate a preference for one of the two when given a mystical explanation of a natural phenomenon and a scientific explanation of the same phenomenon (e.g., disappearance of a ship in the region of the Atlantic Ocean referred to as the "Devil's Triangle").

Explain the importance of using the scientific method in personal decison making.

Indicate their feelings about the notion that scientists have a moral responsibility for the products of scientific investigations (e.g., environmental degradation versus technology, genetic engineering, nuclear bomb).

Pick an issue related to the moral (as opposed to nonmoral, economic or social) obligations of scientists in society from a list of five regarding, e.g., lunar studies, population control, neutron bomb.

Conserve natural resources as a result of their experience in formal science.

Explain a scientific perspective concerning commercially manufactured products.

Explain a perception of the uses of natural resources and manufactured products.

Age 17

Apply proper science terminology to scientific phenomena.

Define scientific terms (e.g., fault, glaciation, galaxy, mitosis, metabolism, diversity, energy, half-life, density) by giving the definition of the term or matching the term to its definition or finishing a completion-type question.

Identify simple laboratory equipment (e.g., magnifying lenses, thermometers, balances, magnets, linear measuring devices, graduated beaker).

Use laboratory equipment (e.g., anemometer, microscope, barometer).

Associate commonly used laboratory equipment with the proper scientific discipline (e.g., a balance for determination of mass, a light meter for determination of light intensity, a geiger counter for determination of radiation).

Distinguish between a chemical element and a compound.

Describe various concepts (e.g., cause-effect, time-space, cycle, organism, entropy, scale).

Explain observations of simple natural phenomena in terms of concepts (e.g., change, equilibrium, invariance, symmetry).

Explain the differences between a planet and star, galaxies and solar systems.

Identify common rocks and minerals.

Identify common cloud formations.

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- Give the names of some characteristics of several groups of organisms (e.g., microorganisms, mammals, birds, reptiles).
- Identify and give the function of common structures related to living things.
- Determine that Mendel's law of dominance is operative when given the color of guinea pig offspring and their parents.
- Determine that the relationship between mass and force is an application of Newton's second law.
- Identify an application of the principle of the inverse square law when given the temperatures of containers of water at various distances from a heat source.
- Properly apply Archimedes' Principle in an explanation of why ships float.
- Determine the effect on the earth's temperature, using the inverse square law, if the earth were to be placed twice as far as it is from the sun.
- Predict F1 and F2 generations when given the genotypes of the parents, using Mendel's law of dominance.
- Identify conceptual schemes (e.g., stratification, diastrophism, ecosystem relationships, structure-function relationships, particulate nature of matter, gravitational and nuclear forces).
- Interpret a sequence of deposits and the formation of geological features.
- Identify the relative ages of rocks, streams, mountains, etc.
- Use the fundamental theme of ecology to organize concepts into a broad scheme.
- Distinguish between component principles and a conceptual scheme.
- Describe common characteristics of elements within a group.
- Observe and describe the properties of metals, living matter, fluids.
- Describe the difference between a rock and a mineral.
- Classify a list of five rocks in more than one way.
- Identify characteristics of living things.
- Identify various categories of classification, recognizing commonly used groupings (e.g., mammal, reptile, bird).
- Identify key characteristics of broad groups of living things (e.g., gymnosperms, angiosperms).

Make valid predictions in interpolation and extrapolation from a set of empirical data shown on a curve.

List the possible reactions which have occurred when a set of solutions interact, forming a precipitate.

Infer possible causes and outcomes from selected scientific phenomena.

Construct more than one inference from a set of data.

Identify components of the heliocentric model of the solar system from a list which also includes geocentric components (e.g., phases of Venus-epicycles).

Select and apply an appropriate model to describe a naturally occurring event (e.g., consumer-producer food chain).

Identify adequate plans for setting up apparatus and for collecting relevant data.

Identify variables that influence a system and name the suitable controls.

Identify variables that influence a system and identify controls in such a way that an experiment can be set up where only one variable is operative.

Distinguish between a hypothesis, a theory and a fact, and choose from a list the most appropriate hypothesis for a given phenomenon.

Identify an appropriate sequence related to laboratory investigation.

Prepare a simple testable hypothesis for a natural phenomenon (e.g., oil is formed from organic material when optimum physical and chemical conditions exist, the population of fruit flies in a vial decreases when the food supply decreases, light intensity decreases inversely to the distance measured from the light source).

Identify a simple hypothesis for a natural phenomenon (e.g., earthquakes, aging, hot air rises).

Interpret functional relationships from a set of data.

Interpret functional relationships, eliminate extraneous data, synthesize data elements, and make extrapolations and interpolations from a set of data (e.g., graphs, diagrams, charts, tables, maps).

List only those variables needed to determine acceleration when given a hypothetical experimental setup to determine the acceleration of a rolling ball down an inclined plane.

Identify the elements (hypothesis, conclusion, data, purpose, method) of a good experimental design.

Put in sequence the elements (purpose, hypothesis, method, data, conclusion) of a good experimental design.

Identify an appropriate sequence related to a laboratory investigation of a scientific phenomenon or conduct an experiment by isolating the problem, gathering data, suggesting hypothesis, developing experiments with variables and controls, interpreting results, drawing conclusions, and making predictions.

- Take additional science courses. (Assessment items should assess student variables through multiple response techniques.)
- Express an attitude toward previous science courses. (Assessment items may emphasize, for example, classroom environment, teacher attitude, enjoyment of previous science classes.)
- Pursue science-oriented hobbies (e.g., collections, clubs, books, games, rockhounding, bird-watching, electronics) as a direct result of taking a science class.
- Indicate the extent to which they see beauty in nature and do science-related things in the outdoors for just sheer enjoyment.
- Explain the necessity and purpose of outside-school agencies (e.g., Department of Land Conservation and Development, Environmental Protection Agency, Department of Energy).
- Name several pros and cons for issues (e.g., strip mining, forest clear-cutting, building large dams).
- Identify which academic areas are most closely associated with science (e.g., mathematics, language arts).
- Identify the correlation between science and social studies, or science and home economics, etc., from a list of correlated and noncorrelated items (e.g., chemistry—dyes in fabrics; ecology—costs in recycling).
- Evaluate whether proper inquiry techniques were used in the solution of a personal problem.
- Select from a list of possible solutions to a problem the one which is both scientific and appropriate.
- Distinguish between nonscience (e.g., astrology, occult) and the unknown or unanswerable at this time (e.g., UFO, ESP).
- Indicate a preference for one of the two when given a mystical explanation of a natural phenomenon and a scientific explanation of the same phenomenon (e.g., disappearance of a ship in the region of the Atlantic Ocean referred to as the "Devil's Triangle").
- Use the scientific method in personal decision making.
- Identify their own attitude toward science and technology.
- Choose the most scientific explanations of contemporary problems in terms of cause and effect.
- Indicate their feelings about the notion that scientists have a moral responsibility for the products of scientific investigations (e.g., environmental degradation versus technology, genetic engineering, neutron bomb).
- Pick and defend an issue related to the moral as opposed to nonmoral, economic or social obligations of scientists in society (e.g., production of plutonium, genetic engineering, laser warfare).
- Identify their attitude about natural resources and match this attitude with an appropriate value context
- Select human welfare and conservation problems from a series of various problems.

Developing Staff Agreement

Success of an instructional program often depends upon gaining consensus among staff to answer such questions as

What is science?
How does science operate?
How should science be taught?
What should be learned?

The agree/disagree instruments here are designed to help staff come to a consensus for effective group instruction. Staff, possibly working under the guidance of the district curriculum coordinator, may use the instruments in a series of discussions to resolve differences, to settle on goals and processes, and to determine needed instructional resources. The general content of these instruments should be viewed in relation to the many other suggestions presented in this *Framework for Science Programs.*

The instruments are followed by a model showing what results might be reported in a hypothetical district.

Adopting basic instructional materials for use in Oregon science classrooms recurs each six years. Establishing the selection criteria and evaluating these materials is the responsibility of the State Textbook Commission. The Commission receives assistance in the evaluation process from numerous text selection committees from throughout the state. Final approval of their recommended adoptions rests with the State Board of Education upon the advice of the Oregon Department of Education curriculum specialist.

Selection criteria and a list of adopted science instructional materials for the 1977-83 science adoption cycle are available from the State Textbook Commission. Procedures for petitioning for the use of instructional materials not on the currently adopted list are available from the School Standardization Section of the Oregon Department of Education.

What Is Science?

Directions

1. On the form check whether you agree, disagree or have no opinion.
2. Small groups should then review all responses. Decide on common descriptors; revise any if needed.
3. Small groups should convene as a whole to determine where they agree or disagree. The whole group should try to resolve any major disagreements so that a single list of attributes can be generated. Considerable rewording may be necessary.

	AGREE	DISAGREE	NO OPINION
Knowledge is derived both through empirical logic and through spiritual insight and/or doctrine.			
Science holds that people can observe, know and understand the universe in which they live.			
Science is not moral and not immoral. Science prefers to maintain a moral neutrality.			

	AGREE	DISAGREE	NO OPINION
Although order exists in the universe, scientists attempt to discover the nature of this order and to specify relationships in terms of precise mathematical formulas.			
All phenomena are a function of prior conditions.			
An essential aim of science is to develop concise generalizations into one consistent principle having broader applicability.			
A hypothesis is essentially a guess, perhaps an informal one.			
The data of science must be regarded as provisional and subject to change, because errors are continually being made.			
All events are determined or caused.			
A scientific hypothesis is amenable to testing (by scientific techniques, preferably by experimentation).			
Change in scientific knowledge occurs in at least two ways: new knowledge fills in gaps and replaces or modifies previous knowledge.			
Nothing in science is finally proved. The content of science is always tentative.			
The simplest of a group of theories which account with equal adequacy for phenomena, the nature or causes of which are unknown, is the theory most acceptable to science, other things being equal.			
Science investigates occurrences with the assumptions that finite, or natural, determiners underlie these occurrences, and that the occurrences are partially explainable in terms of these eliciting factors.			
Science is concerned with formulating general laws, not merely categorizing the data.			
Science may be most effective in giving us knowledge of the world we live in, but it is not self-sufficient methodologically, nor is it instrinsically capable of dealing with the whole of human experience.			
Probably the only permanent characteristic of scientific knowledge is the nature of that knowledge as contrasted to the knowledge itself. There is no doubt that scientific knowledge, as such, is in a continuous state of change.			
Investigation of the ultimate or original or prime causation is of less concern to scientists than more immediate causation.			
Science cannot segregate itself from society. It is, in fact, a product and a part of society and its morality; and science continues to exist only because social attitudes support it, or, at least, are not generally and violently opposed to it			

	AGREE	DISAGREE	NO OPINION
Caution and skepticism are characteristic of and fundamental to science.			
Scientists, when faced with partially explainable phenomena, may never subscribe to notions of the intervention of supernatural influences.			
Science, insofar as it aims at the formulation of laws, aims also at explanation rather than at mere description. But the search for laws determines in large measure the nature of scientific methods.			
Science is the systematized knowledge of any one department of mind or matter. It is acknowledged truth and laws.			
To scientists, a hypothesis is similar to a theory, except that it is narrow in the sense that it attempts to explain or account for narrow ranges of phenomena.			
A theory may be defined as an explicit and objective statement of surmise or speculation which integrates isolated bodies of data into a coherent and consistent framework.			

How Does Science Operate?

Directions

1. On the form check whether you agree, disagree or have no opinion.

2. Small groups should then review all responses. Decide on common descriptors; revise any if needed.

3. Small groups should convene as a whole to determine where they agree or disagree. The whole group should try to resolve any major disagreements so that a single list of attributes can be generated. Considerable rewording may be necessary.

	AGREE	DISAGREE	NO OPINION
An objective means of describing the data of science is to specify the steps (techniques, procedures, processes, etc.) by which phenomena are observed, measured or recorded.			
The intellectual processes of science are not totally isolated from the other dimensions of scientific literacy. Classifying and the concept of "population" are linked, since doing the former results in the latter. In a similar way the probabilistic nature of science imposes certain qualities on the conclusions drawn in the process of interpreting data.			
Classifying, inferring, observing, using numbers and predicting are basic scientific process skills because each does not include any other process skill.			

	AGREE	DISAGREE	NO OPINION
Some phenomena may be known immediately through innate or spiritual means, without direct observation and without inference from prior data.			
People can understand natural phenomena by directly attending to natural phenomena.			
Communicating is a basic process skill of science that carries information from person to person and incorporates any one of several procedures involving various media.			
Every tenet is open to investigation, or it may not be associated with science.			
Formulating models may be defined as planning a series of data-gathering operations that will provide a basis for testing a hypothesis or answering a question.			
Two examples of models would be the Biblical account of creation and Darwinian theory of evolution.			
Scientifically literate persons use processes of science in solving problems, making decisions and furthering their own understanding of the universe.			
Deduction is the fundamental logic of science.			
Not all knowledge is derived from inference or from sensory observation.			
The scientific method may be divided into a number of steps. Into how many steps the method is divided is something of an arbitrary matter, perhaps dependent mainly upon the refinement of consideration desired.			
When conflict exists in science between statements of authority and empirical findings, this conflict must be resolved.			
Science operates from new knowledge primarily achieved by inference from prior concepts or information, some of which may be innate.			
Observation is the basic process of science, persons using their senses to obtain information about the world.			
Predicting and hypothesizing have similar definitions.			
Defining operationally means producing definitions in terms, physical descriptions, or results from conducting given procedures.			

How Should Science Be Taught?

Directions

1. On the form check whether you agree, disagree or have no opinion.

2. Small groups should then review all responses. Decide on common descriptors; revise any if needed.

3. Small groups should convene as a whole to determine where they agree or disagree. The whole group should try to resolve any major disagreements so that a single list of attributes can be generated. Considerable rewording may be necessary.

	AGREE	DISAGREE	NO OPINION
The approach should be that of discovery. A laboratory or experimental exercise utilizes discovery. Answers to questions are not valued as being right or wrong, but are interpreted only in reference to data gathered as it compares to the question asked.			
The program should be sequential. The sequence should be based on the developmental capabilities of students.			
The program should be organized to teach concepts, processes and scientific values. These are reflected in the course goals.			
The program must allow time for student reflection, collateral reading, independently designed creative pursuits.			
Courses should probe the depth of the subject matter, not necessarily its breadth; they should strive to provide conceptual syntheses of diverse data, not simply disconnected catalogs of so-called facts; above all, they should point the way toward real comprehension of significant ideas, not just require meaningless memorization.			
The program must encourage appreciation of scientific contributions in modifying and improving ways of life, and the challenges they pose.			
The program should not be heavy with current, specific knowledge and its details. This temporary knowledge is too often presented and absorbed as literal truth. Thus, many people have learned (and some even retain) the details of a specific model for an atom without ever having learned the nature and role of a model in science. People with this experience may mistakenly believe they are scientifically literate just because they can recite the number of electrons and their configuration in an atom of carbon.			
The program should emphasize generalizations—big ideas of science studied in more contexts than a single specialized science.			
The program should stress a coherent subject matter context or framework, because unified science courses stressing generalized ideas, without contextual references to one or more of the specific disciplines of science, do not provide students with frames of reference they need to relate ideas and principles to conceptual schemes.			

	AGREE	DISAGREE	NO OPINION
The program should stress science facts and concepts at the lowest levels and the application of scientific laws and principles at the highest.			
The program should provide for assessment to assure all program goals are being achieved.			
The program should stress the appreciation of the learning and the scientific processes as well as the social relevance of science and technology.			
The program should emphasize the use of scientific processes in personal decision making.			
The program should be broad in scope—transdisciplinary, seldom exploring a single field of science for any length of time.			
The program should explore many disciplines within science, but in some coherent format that stresses principles and concepts in earth, life and physical sciences.			
At the elementary level, the program should stress facts and simple concepts related to various fields of science, but most of all it should emphasize process skills and positive attitudes.			
The junior high school program should stress the higher process skills, such as controlling variables. It should also stress the principles and concepts of earth, life and physical sciences.			
At the senior high level, more attention is paid to the cognitive aspects of science. *Processes are not taught for themselves alone, but as tools to be used. Content should be sufficiently open-ended to allow for some student investigation.*			
The secondary program should be comprehensive, encouraging all students to participate. Science education is not elitist.			

What Should Be Learned?

Directions

1. Under **OPINION** check whether you agree, disagree or have no opinion.
2. If you agree, where would you include the idea in the curriculum (checking more than one level if you think it appropriate).
3. In small groups, categorize all acceptable goals into some appropriate classification system.
4. Reconvene as a whole to share ideas and to combine schemes.

	OPINION			GRADE LEVELS			
	AGREE	*DISAGREE*	*NO OPINION*	K-3	4-6	7-9	10-12
Students will recognize and apply appropriate terminology to describe familiar scientific phenomena.							
Students will recognize simple science equipment and identify their functions.							
Students will know and apply facts and simple concepts of earth, life and physical sciences.							
Students will know which scientific principle and law is appropriate to given situations in earth, life and physical sciences.							
Students will apply scientific principles necessary for the solution of problems in earth, life and physical sciences.							
Students will recognize and identify fundamental themes that pervade particular and broad fields of science.							
Students will be able to organize related concepts into broad schemes.							
Students will be able to observe and describe properties of objects.							
Students will be able to classify.							
Students will be able to use and apply common scientific and mathematical symbols.							
Students will be able to make and use reasonable predictions.							
Students will be able to make reasonable inferences.							

	OPINION			GRADE LEVELS			
	AGREE	DISAGREE	NO OPINION	K-3	4-6	7-9	10-12
Students will be able to formulate models—devise mechanisms, schemes or structures that will act or perform as if they were specific real objects or events.							
Students will be able to control variables—identify and manage factors that may influence a situation or event so that the effect of a given factor may be learned.							
Students will be able to state a tentative generalization, but it is subject to immediate or eventual testing.							
Students will be able to find a pattern or other meaning inherent in a collection of data.							
Students will be able to experiment—plan a series of data-gathering operations which will provide a basis for testing a hypothesis or answering a question.							
Students will value taking additional science as essential to their own well-being.							
Students will value science in nonformal settings (e.g., hobbies).							
Students will value aesthetics in science.							
Students will value the application of science content to other areas of the school program.							
Students will value the use of scientific processes in decision making.							
Students will value application of science to technology and technology to society.							
Students will value the moral obligation of science to society.							

hypothetical results in one district

What Is Science?

Consensus

Science and People

Science holds that people can observe, know and understand the universe in which they live.
Science may be most effective in giving us knowledge of the universe but it is not capable of dealing with the whole of human experience.
Science cannot segregate itself from society. It is, in fact, a product and a part of society.
Science is not moral and not immoral. Science prefers to maintain a moral neutrality.

Scientific Laws, Theories and Hypotheses

A theory may be defined as an objective statement or speculation which combines bodies of data into a coherent and consistent framework, the simplest of which is the theory most acceptable to science.
Science attempts to discover the nature of orderliness in the universe and specify relationships in the terms of theories and laws, not merely catagorizing the data.
A hypothesis is essentially a guess, perhaps an informal one.
A scientific hypothesis is similar to a theory, except that it is narrow in the sense that it attempts to explain or account for narrow ranges of phenomena.
A scientific hypothesis is amenable to testing by scientific techniques, preferably by experimentation.

Change in Science

Science states that all phenomena are a function of cause and effect.
Science must always approach partially explainable phenomena objectively.
Attitudes of caution and skepticism are characteristic and fundamental and the data of science must be regarded as provisional.
Changes in scientific knowledge occur in at least two ways—new knowledge is discovered to fill gaps in previous knowledge and old knowledge is replaced or modified.

How Does Science Operate?

Consensus

Basic Scientific Processes

Observing is the most basic process of science. Observing means using the senses to obtain information or data about objects and events.
Relating time-space means describing spatial relationships and their change with time. These can be grouped into five categories: shapes, direction and spatial arrangement, motion and speed, symmetry, and rate of change.
Classifying is the process scientists use to impose order on collections of objects or events. Classification schemes are used in science, as well as in other disciplines, to identify objects or events and to show similarities, differences and interrelationships.
Using numbers is another basic scientific process. Numbers are needed to manipulate measurements, to order objects and to classify objects.
Measuring is the process to quantify observations. Skill is needed in using measuring instruments properly. Ability to carry out calculations with these instruments is essential. The process involves judgment about which instrument to use, and when approximate rather than precise measurements are acceptable.
Communicating clearly and precisely is fundamental to all scientific work and essential to all human endeavors. Communication involves oral and written words, diagrams, maps, graphs, mathematical equations and visual demonstrations.

Predicting involves a specific forecast of what a future observation will be. Predictions are based on observations, measurements and inferences about relationships between observed variables.
Inferring is using logic to draw conclusions from what is observed.

Integrated Scientific Processes

Controlling variables involves managing the conditions of an investigation.
Interpreting data involves making predictions, inferences and hypotheses from data collected in an investigation.
Formulating hypotheses involves forming a generalization that includes all objects or events of the same class.
Defining operationally means defining terms in the context of previous experience.
Experimenting is the process that encompasses all basic and integrated processes. Experimenting usually begins with observations that suggest questions to be answered. A hypothesis may be formulated from the question or questions. The succeeding steps involve identifying the variables to be controlled, making operational definitions, constructing a test, carrying out the test, collecting and interpreting data, and, sometimes, modifying the hypothesis being tested.

Methods of Science

Science is the systematized knowledge of any one department of mind or matter; it is acknowledged truth and laws. The search for laws determines in a large measure the nature of scientific methods used.
The scientific method may be divided into a number of steps, depending on the refinement desired.
An objective means of describing the scientific method is to specify steps, i.e., the techniques, procedures, processes, etc., by which the phenomena were observed, measured or recorded.
Formulating models may be defined as planning a series of data-gathering operations that will provide a basis for testing a hypothesis or answering a question.
Scientifically literate persons use processes and methods of science in solving problems, making decisions, and furthering their own understanding of the universe.
When conflict exists in science between statements of authority and empirical findings, this conflict must always be resolved.

How Should Science Be Taught?

Consensus

K-3

The program should use techniques that capitalize on teachable moments, use community resources effectively, and provide stimulating and appropriate activities with ample opportunity for children to question, explore and experiment.

4-6

At the elementary level the program should present facts and simple concepts emphasizing process skills and positive attitudes.
The program should be broad in scope and transdisciplinary, exploring many fields of science.

7-9

The junior high school program should utilize the highest process skills (e.g., controlling variables).
The program should also stress the principles and concepts in earth, life and physical sciences.

10-12

At the senior high level the cognitive aspects of science are emphasized.
The program should be sufficiently open-ended to allow for student investigations.
The program should stress a coherent subject matter, context or framework to provide a student with the frame of reference needed to organize ideas and principles into conceptual schemes.

The program should be comprehensive and allow alternatives to attract all students.

7-12

The program should explore many disciplines of science in a coherent format that stresses principles and concepts in earth, life and physical sciences.

K-12

The program should be a sequence based on the developmental capabilities of the students.
The program should be organized to teach concepts, processes and skills specified in the course goals.
The program should provide awareness and appreciation of the learning and scientific processes, including the relevance of science and technology to society.
The program should provide career education at all levels.
One approach is that of discovery. A laboratory of experimental exercise utilizes discovery when it seeks to derive an answer to a question from the apparatus, organism, situation or experimental design to which it is directed. The answers to posed questions are not valued as being right or wrong, but are interpreted only in reference to the data gathered as it compares to the question asked.
The program should be concerned with the practical use of scientific processes and methods in personal decision making.

What Should be Learned?

Consensus

This section is divided into three parts.

Process—includes both basic and integrated process skills. These are defined earlier in the category "How Does Science Operate?"
Content—includes the specific science knowledge or facts studied.
Affect—includes values as applied to classroom activities, including such areas as hobbies and the relationship of science to society.

Symbols and Definitions

I = *Introduce*—the first time a goal will be presented as a part of a learning experience
M = *Maintain*—continue to present and reinforce previously introduced goal
E = *Emphasize*—goal to be stressed; the main goal to be taught
O = *Not Covered*—goal not covered at a given level

PROCESS

Basic	K-3	4-6	7-9	10-12
Students will observe and describe properties of objects.	I	E	M	M
Students will use time-space relationships.	I	E	M	M
Students will classify.	I	E	M	M
Students will use instruments for measuring.	I	E	M	M
Students will organize a logical sequence of thought, both verbally and in written form (communication).	I	M	E	E
Students will make and use reasonable predictions.	I	E	E	E
Students will make reasonable inferences.	I	M	M	E
Integrated				
Students will identify and manage factors that may influence a situation or event, so that the effect of a given factor may be learned—control variables.	O	I	M	E

	K-3	4-6	7-9	10-12
Students will find a pattern or other meaning inherent in a collection of data.	I	M	M	E
Students will state a tentative generalization that may be used to explain a relatively large number of events, but which is subject to immediate or eventual testing by experimentation—hypothesize.	O	I	M	E
Students will determine meanings in the context of their own experience—define operationally.	O	I	M	E
Students will plan a series of data-gathering operations which will provide a basis for testing a hypothesis for answering a question—experiment.	O	I	I	E
Students will organize related concepts into broad schemes.	O	I	M	E
Students will apply appropriate scientific principles and laws for problem solving to given situations in earth, life and physical sciences.	O	O	I	E
Students will devise mechanisms, schemes or structures that will act or perform as if they were specific real objects or events—formulate models.	O	O	I	E

CONTENT

Students will use and apply common scientific and mathematical symbols.	I	M	M	E
Students will recognize and apply appropriate terminology to describe familiar scientific phenomena.	I	M	M	M
Students will recognize simple science equipment and identify its function.	I	M	M	M
Students will know and apply simple concepts of earth, life and physical sciences.	I	M	E	E
Students will recognize and identify fundamental themes that pervade particular and broad fields of science.	O	I	M	E

AFFECT

Note: Goals are grouped according to
A = values as applied to a classroom setting
B = hobbies, etc.
C = science and society
Some crossover, as would be expected, appears in the listing below.

A - Students will value taking additional science.	I	M	E	E
A - Students will value aesthetics in science.	I	M	M	M
A - Students will value the application of science content to other areas of the school program.	I	M	E	E
B - Students will value science in nonformal settings (e.g., hobbies).	I	M	M	M
C - Students will value the use of the scientific process in personal decision making.	I	M	M	M
C - Students will value recognition of the moral neutrality of science.	I	M	M	M
C - Students will value application of science to technology and technology to society.	O	I	M	M

Guidelines for Self-Assessment of Secondary School Science Programs

The National Science Teachers Association has prepared *Guidelines for Self-Assessment of Secondary School Science Programs* (1975). These guidelines have four parts, or modules: *Our School's Science Curriculum* (Stock No. 471-14672); *Our School's Science Teachers* (Stock No. 471-14674); *Science Student/Teacher Interactions in Our School* (Stock No. 471-14676); *Facilities and Conditions for Science Teaching in Our School* (Stock No. 471-14678). The guidelines offer ideas and a means for concerned persons to do a searching, comprehensive examination of science teaching in their own secondary schools. Underlying the preparation of the document is a basic assumption: teachers, students, parents and concerned citizens of a community are, or should be, interested to know why their school has a science program, what it consists of, how well it is supported, and how well it works. The guidelines invite self-examination, self-assessment aimed at finding answers to two questions: (1) What do we want the science program in our school to be and to accomplish? (2) Are we doing what we wanted?

Any one or all of the four modules may be used for a self-assessment. Considerable time will be needed to assemble the team(s) required, to hold preliminary meetings and discussions, to set work procedures and schedules, and, of course, to do the actual assessment.

Listed below are a few suggestions on how to begin a self-assessment in your school.

Decide on specific persons appropriate to be invited to serve on your self-assessment team(s). Invite them, telling them the purposes, procedures, and tentative time schedule for the task.

Convene the team(s) for preliminary discussion, questions, and clarification. Try to develop common understandings and agreement on which module(s) to use and how to proceed.

Initiate the self-assessment. Follow the suggestions and guidelines set forth in each module. Have team members engage in discussions as needed to arrive at consensus on the ratings to be assigned to the various self-assessment items.

Enter all final assessment ratings on a master copy of the assessment module(s) and make plans for final reporting, follow-up actions, publicity, etc.

Reasons for doing a self-assessment may have to come from within. The science teachers themselves may have to initiate it, then win support and cooperation from the administration, students, parents and other community representatives. No national standards must be met; no norms must be compared. The assessment must be a local, self-contained, internal effort, a comparison of *what is* with *what is wanted* in the local school situation.

Scales are used to rate such considerations as preparation, professional activities, attitudes, and more.

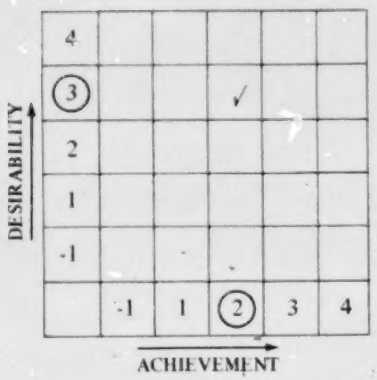
desirability for OUR school

4	very desirable, of utmost value
3	desirable, of significant value
2	moderately desirable, of medium value
1	unimportant, of insignificant value
-1	undesirable, of negative value

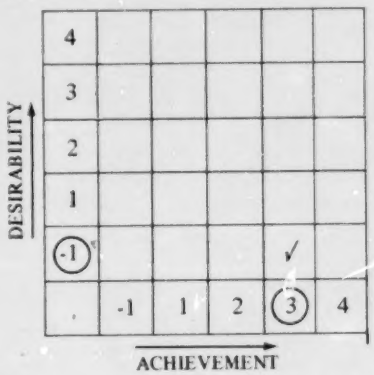
achievement in OUR schools

4	excellent, outstanding
3	very good, above average
2	moderate but significant, about average
1	low (small) achievement or practice, below average
-1	avoided or counteracted

At the right of each item is a small matrix in which the rating is recorded. The vertical axis represents **DESIRABILITY**. Circle the rating you wish to give to desirability. The horizontal axis represents **ACHIEVEMENT**. Circle the rating you wish to give to achievement. Then, for the score on this item, place a check mark in the box where these ratings intersect. Thus, an item that was thought "very desirable" but only "moderately achieved" would be recorded as follows:



An item considered undesirable but found to be present to a high degree would be recorded as follows:

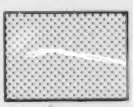


The ratings developed by the various assessment teams as they evaluate each of the items in the modules are to be included in the following matrices of the self-assessment instrument.

An examination of these ratings should be useful in diagnosing areas of strength that should be maintained and areas of weakness that need attention. After all ratings have been entered in the matrices, interpretation of these ratings will be assisted by applying a shaded key matrix with meanings as follows:

Scores in this area of the matrix indicate important goals being achieved and undesirable features being avoided.

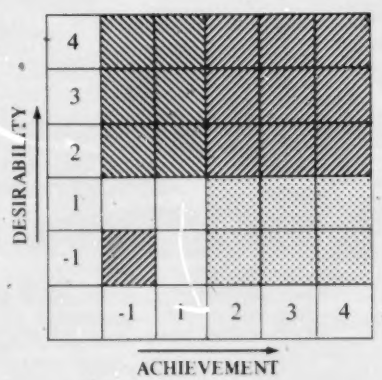
Scores in this area reflect items on which more time, energy and resources may be being spent than is justified by expectations.



Scores in this area indicate items on which existing performance or conditions fall short of expectations.

Scores in this area represent rather neutral items which probably deserve little or no further attention.

Heavy loading in the upper areas of the summary indicates a generally high level of awareness and expectation. Heavy loading the lower areas may, on the other hand, indicate generally low expectations or apathy about conditions.



Orders for all or part of *Guidelines for Self-Assessment of Secondary School Science Programs* should be sent to the

National Science Teachers Association
1742 Connecticut Avenue NW
Washington, DC 20009
(202) 265-4150

Each module costs $1.00. The complete set costs $5.00. Mailing costs $.50 *per order*.

self-assessment checklist for science teachers

The following statements characterize good science teachers. Statements have been put into a checklist to help teachers determine how they compare.*

Scientific Attitudes, Thinking Processes, Skills, Knowledge, Liberal Arts

		Low				High
1	My students see in me an attitude of open-mindedness and suspended judgment.	1	2	3	4	5
2	I enjoy designing and conducting experimental studies to test hypotheses or account for discrepant events.	1	2	3	4	5
3	I willingly subject personally acquired data and ideas to peer criticism.	1	2	3	4	5
4	I am proficient in manipulating and utilizing the tools and equipment of science.	1	2	3	4	5
5	I am able to apply mathematics to gathering, processing and communicating data in my teaching.	1	2	3	4	5
6	I can use oral and written communication skills effectively.	1	2	3	4	5
7	I am familiar with the basic recognition and recall content of my field and level of science.	1	2	3	4	5
8	I understand the factors affecting the physical, emotional and intellectual growth and development of my students.	1	2	3	4	5
9	I can identify and construct conditions that motivate inquiry in the learner.	1	2	3	4	5
10	I use effective methods and materials to guide students in their consideration of science-related careers.	1	2	3	4	5
11	I seek to know, understand and support the needs, aspirations and positive attitudes of the community toward education.	1	2	3	4	5
12	I interact and cooperate with other teachers in providing a healthy, balanced total school atmosphere.	1	2	3	4	5
13	I am aware of community resources that will enhance my science instructional program.	1	2	3	4	5
14	I can describe the interrelationships among various fields of science.	1	2	3	4	5
15	I know of scientists in my community and can relate them to my instructional program.	1	2	3	4	5
16	I work with other teachers to interrelate the teaching of science with other subjects.	1	2	3	4	5
17	I can interpret the relationships between science and other aspects of human endeavor.	1	2	3	4	5
18	I have developed and follow a philosophy of education which deals with the place of science teaching in the school's total education effort.	1	2	3	4	5
19	I am aware of energy/ecological relationships in the environment and of their social and economic implications.	1	2	3	4	5
20	I have studied the social/economic/environmental impacts of science and the social and moral responsibilities of scientists.	1	2	3	4	5

*Adapted from the California State Curriculum Framework and Criteria Committee for Science adaptation of National Science Teachers Association evaluative criteria

Instructional Methods and Techniques

		Low				High
1	I use specific course and curriculum development techniques (lesson plans, minicourses, learning activity modules, goals and performance indicators, etc.).	1	2	3	4	5
2	I know where to obtain and how to use data (about each learner's knowledge, interests and abilities) to provide unique individual experiences.	1	2	3	4	5
3	I can effectively utilize current technological devices and materials in my teaching (e.g., motion pictures, overhead projectors, audio- and videotape recorders, and computer time-share).	1	2	3	4	5
4	I can select, construct, use and interpret various kinds of evaluation instruments for determining student progress.	1	2	3	4	5
5	I utilize a variety of teaching styles (i.e., student inquiry, lecture, demonstration, individual project work, convergent and divergent questioning, seminars, simulations).	1	2	3	4	5
6	I make provisions for the safety of students' participation in classroom/laboratory activities and can handle emergencies that arise.	1	2	3	4	5
7	I implement a variety of forms of classroom organization: individual, small and large group, open classroom, laboratory, team teaching.	1	2	3	4	5
8	I can provide a rich environment (of data sources, materials for experimentation, phenomena to observe, ideas) for use by my students in reaching course goals.	1	2	3	4	5
9	I am familiar with the legal requirements relative to the care and use of animals in the classroom in my instructional program.	1	2	3	4	5

Professional Education and Development

1	My background equipped me with the understanding of the earth, life and physical sciences needed for teaching in my current assignment.	1	2	3	4	5
2	I have a working knowledge of recent national curriculum projects (e.g., SAPA, ESS, SCIS [elementary] or ISIS, BSCS, ISCS, CHEMS [secondary]).	1	2	3	4	5
3	I participate in the activities of at least one (national, state or local) organization primarily related to science teaching (e.g., the National Science Teachers Association, Oregon Science Teachers Association).	1	2	3	4	5
4	I attend the conferences and conventions held by national, state or local organizations related to my field of science interest (AAPT, ACS, NABT, NAGT, NSTA) whenever locally held.	1	2	3	4	5
5	I have attended one or more special inservice programs for science teaching (e.g., summer institute, inservice institute, inservice course) in the past two years.	1	2	3	4	5
6	I contribute to the development or evaluation of new programs and ideas in science teaching (e.g., participate in or conduct a research study, develop innovative curriculum materials, pilot test newly developed materials).	1	2	3	4	5
7	I participate in the science teacher preparation programs of nearby colleges and universities by working with student teachers and/or teaching extension courses.	1	2	3	4	5
8	I use professional days or released time to visit other schools and observe innovative science programs and outstanding teachers in action.	1	2	3	4	5
9	I use my training and experience to identify students with special needs or problems and refer them to persons or agencies qualified to provide help.	1	2	3	4	5
10	I am familiar with the special science-related opportunities (clubs, competitions, fairs, symposia, congresses) available to my students and encourage and advise them in their participation.	1	2	3	4	5